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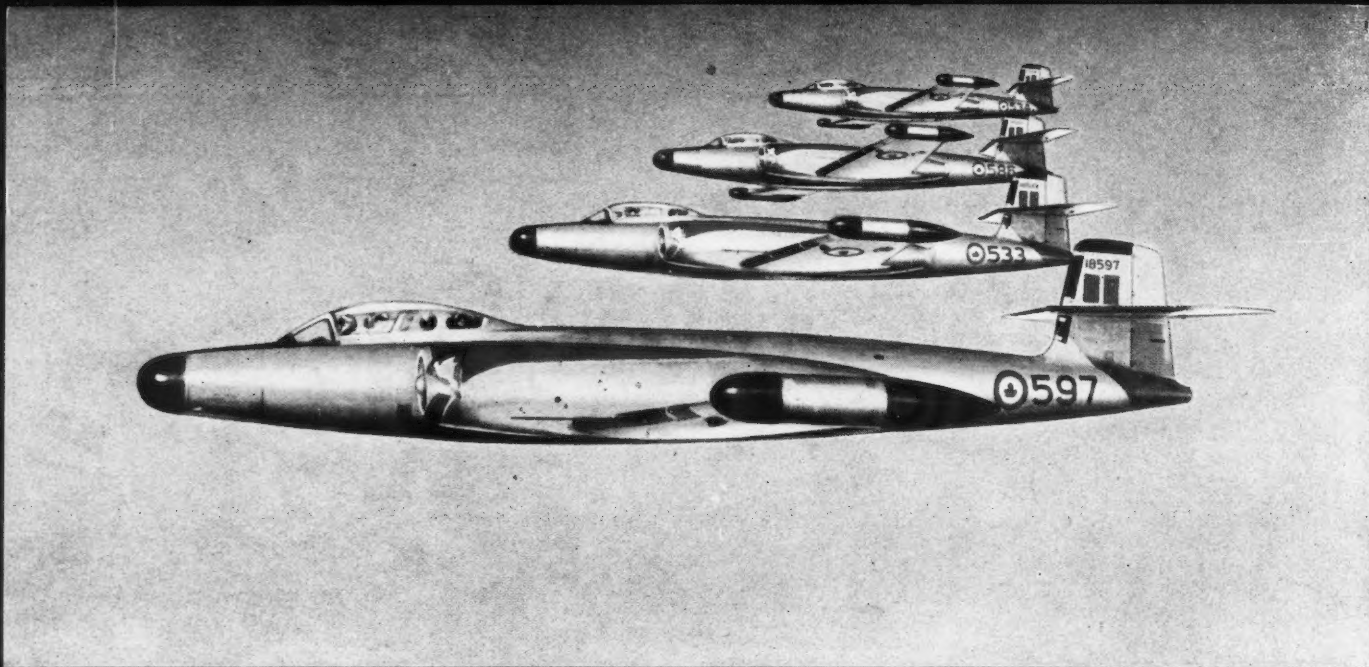
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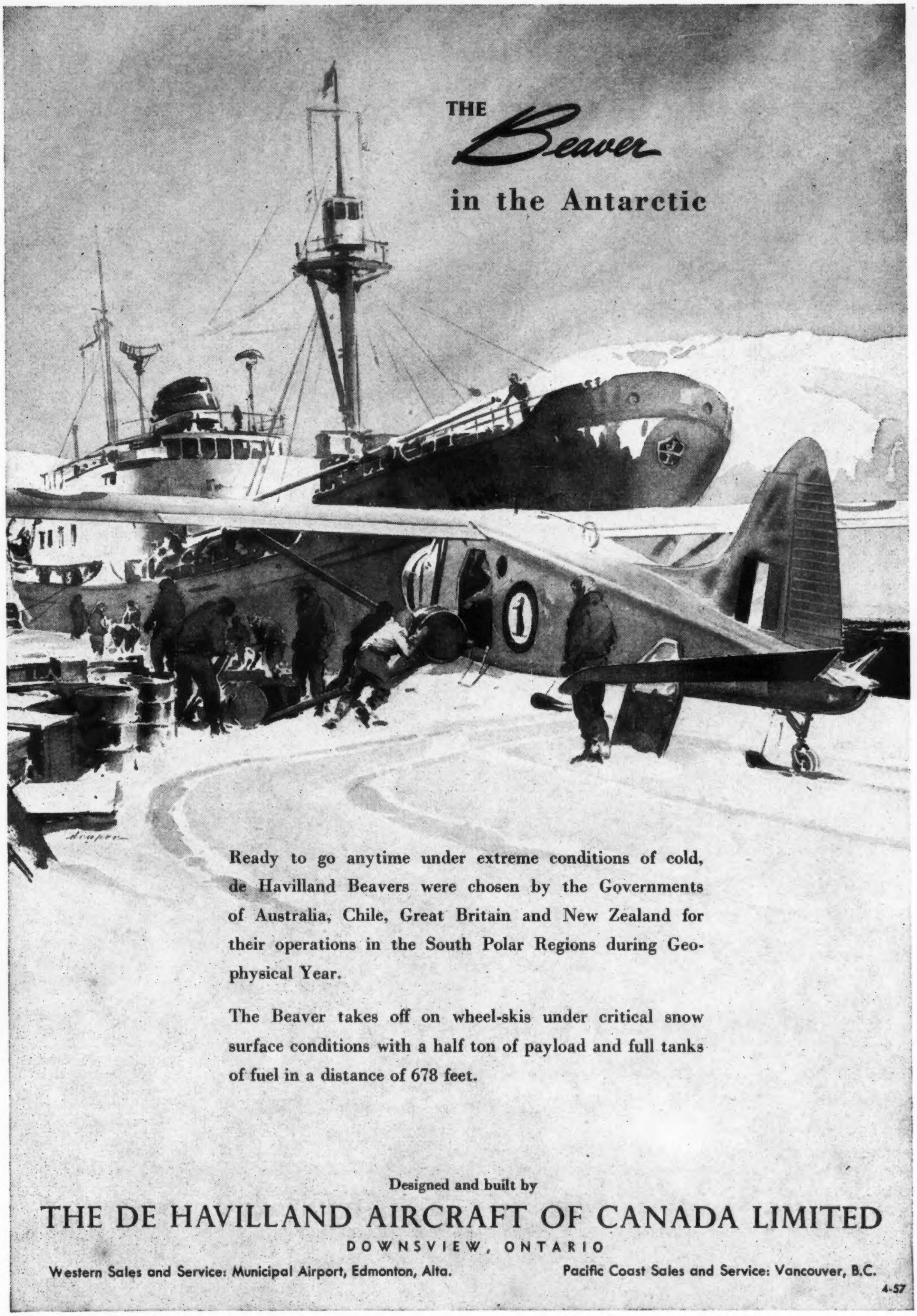
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CANADIAN AERONAUTICAL JOURNAL

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ARCTIC MULES

National Defence Photo

RCN helicopters operating from the Arctic patrol ship HMCS Labrador earned the name "Arctic Mules" for their service and versatility. The Vertol was used for freighting men, equipment and survey apparatus to inaccessible places and the Bells for ice reconnaissance.

EDITORIAL

SPECIALIST SECTIONS

THE Test Pilots Section of the Canadian Aeronautical Institute has now been in being for a year and is likely to be followed by the formation of other Sections composed of groups of members with common specific interests within the broad terms of aeronautical science. The possibility exists, for example, that those particularly concerned with rocket flight, aircraft propulsion, aerodynamics or perhaps aircraft maintenance would benefit by closer association as Sections and this, in turn, could increase the overall usefulness of the Institute.

The formation of the Test Pilots Section was a "natural". The various individuals and groups of Canadian test pilots have always felt an affinity of spirit but a remoteness of contact because of their geographic dispersion across our country from coast to coast. Also, until recently, they were considerably separated in types of aircraft and types of test flying. This latter factor is becoming steadily modified by the common denominator of jet aircraft, as almost all companies now have some type of test program involving the flying of jets. This has meant that, while the test pilots of each of the companies have individual problems peculiar to their own type of aircraft or their own locality, they all encounter common problems involved in the flying of high performance jet aircraft at high speeds and high altitudes.

These pilots realized that coordination would be better than isolation and were most receptive to an invitation to attend a general meeting of all Canadian test pilots sponsored by the Central Experimental and Proving Establishment in Ottawa in March, 1956. In all, some 60 test pilots were present at this first meeting and the chief pilots of the various companies and units presented briefs on their particular facilities, operations and problems.

Many test flying problems created by the increased performance of modern jets have been solved but many still remain. Those of particular concern to the test pilots are in the areas of the design of safety equipment and ejection mechanisms; the difficulty of establishing a satisfactory routine of close integration between the experimental test pilots and the design teams; the delays in test flying programs, both experimental and production, as a result of unfavourable weather; the conflicting methods and requirements of the many design and test flying specifications now in use and the problem of training enough new test pilots to meet the increasing demand for high technical skills.

It was the joint discussions of these and other problems of our work which prompted a determination to form an association of Canadian test pilots.

Our first intention was to establish an independent society but careful consideration led to an appreciation of the benefits to be derived from allying a small new group to an already well established large organization, such as the Canadian Aeronautical Institute. This would provide an approved constitution on which to base a set of by-laws. It would provide an efficient central office for distribution of information, correspondence and literature to the various test pilots across Canada. But, perhaps even more important, it would serve to identify the test pilots with a highly respected technical organization composed of members concerned with other aspects of the same problems and all engaged in industry, in the Services or in scientific establishments with the one aim of keeping Canada a leader in the field of aeronautics.

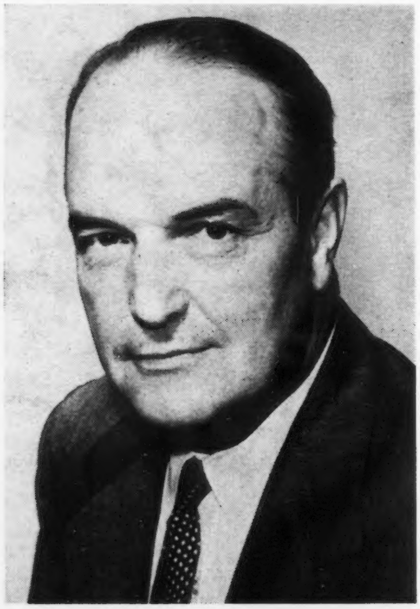
We are proud, indeed, to have become a Section of the Canadian Aeronautical Institute dedicated to the advancement of the art and science of test flying in the Canadian environment and we look forward to the formation of other Specialist Sections in the near future.

D. H. ROGERS
Chairman, Test Pilots Section

THE ECONOMICS OF CIVIL TURBINE OPERATION†

by G. R. McGregor*

Trans-Canada Air Lines



Mr. G. R. McGregor

At the outset I would like to express gratitude to your Council for affording me the opportunity to speak to this joint meeting of the Canadian Aeronautical Institute and the Institute of the Aeronautical Sciences.

Secondly, I must apologize in advance, particularly to the ladies, for the fact that this talk deals with economics, which, after all, is only a highbrow name for money.

It is a great pity that such a beautiful thing as a modern aeroplane must still be regarded by the professional operator as a machine capable of either making or losing money for the company which owns it.

Perhaps we should be consoled by the fact that even that wonderful flight mechanism, the Canada Goose, must observe some of the rules of the economics of flight. Those birds, having spent the summer in the very far north and having given their children all the knowledge that they must have for long range flight, move south by easy stages into autumn feeding grounds, such as the southern tip of James Bay. There they eat virtually around the clock for two or three weeks, in order to, in effect, lay in a sufficient supply of fuel for the 2,000 mile non-stop migration flight to the south.

To return to the subject, the economics of turbine aircraft is a matter of great importance at this time to every major airline in the world. I use the general term "turbine aircraft" to cover the whole range of aircraft powered by turbine propeller, turbojet and turbojet bypass engines.

Since, if it is to stay in business, an airline must not consistently lose money and since, if it is to have any customers, its aircraft must be both fast and comfortable, it follows that it must buy aircraft which are at least as fast and comfortable as those operated by other airlines, and also be capable of economical operation over the routes to be served.

Therefore, economics play a major role in the very intricate and detailed studies which are a preliminary to an airline's selection of the types of aircraft which it will buy. These planning studies have something of the fascination of Russian roulette, for the obvious reason that even a small miscalculation can result in the financial suicide of an airline.

From this point on, I hope you will forgive me for references to Trans-Canada Air Lines, my excuses being, firstly, that I am much more familiar with its planning than that of any other airline and, secondly, both in the matter of route pattern and volume of traffic handled, TCA is quite representative of a group of the larger carriers in the industry.

BASIC CONSIDERATIONS

As briefly as possible, I will outline the general problem of aircraft type selection.

Capacity and fleet size

The volume of business of all major airlines has grown and continues to grow rapidly. 15% per year would be a fairly close average rate of growth for the industry. Therefore, an airline's equipment plans must provide not only for the replacement of aircraft in service which are in varying stages of obsolescence, but for additional capacity required to meet growth in the volume of business.

†Dinner Address read at the Joint I.A.S./C.A.I. Meeting in Montreal on the 21st October 1957.
*President.

In this connection, it is interesting to note that as the size and speed of aircraft increase, additional capacity becomes available without necessarily increasing the numerical size of the fleet. For instance, TCA expects to be operating approximately the same number of aircraft in 1961 as in 1958, although the transportation capacity of the 1961 fleet will be more than one and a half times that of the 1958 fleet.

The first step in fleet planning, then, is to make the most accurate possible forecast of the transportaiton market available to the company for each of the succeeding ten years, subdivided into major route segments.

Route pattern and Aircraft types

With the size of the various components of the overall job to be done thus established, it is then necessary to determine the number of different aircraft types which must be operated.

Obviously it is of the greatest importance that the number of types be kept to a practical minimum. Multiplicity of type drives operating costs sharply upward by increasing both air and ground crew training costs, increasing spare parts inventories and increasing the company's requirements for ground equipment.

On the other hand, it is equally uneconomical, in the interests of minimizing the number of different aircraft types in a fleet, to operate an aircraft over a route for which that particular type is inherently unsuited. It would, for example, be physically possible to operate a trans-Atlantic type aircraft between Montreal and Ottawa. To do so would deteriorate the service, because one or two such flights a day would provide sufficient seats, but would not meet the public requirement for a substantial number of flights operating at different times.

Secondly, the cost of operating an aircraft with 3,000 miles range over a route 120 miles long would be considerably greater, with the result that either the company would lose money or the price of a ticket would become prohibitive.

TCA's shortest route is that between Vancouver and Victoria, 47 miles, and its longest, London, England to Toronto, 3,645 miles. Between these two extremes lie a vast number of routes of varying lengths and varying traffic volumes.

Analysis of this problem brought about the decision that, as of 1961, the public would be best served and the economic requirements best met by the operation of an all turbine fleet of three different types.

Staggered obsolescence

An airline must so conduct its affairs as not to be confronted at any one time with the condition in which a large part of its fleet must be replaced in a short period of time.

TCA is in a comfortable position in this respect, with a quite wide spacing in degree of obsolescence applying to each of the four types presently in service. The oldest, the DC-3, and the only unpressurized aircraft which the company operates has been in process of retirement for over a year. The newest, the Viscount, is the most modern aircraft type in service on this continent and will be with us for many years to come. Were this not the case, at some time in the distant future the company would be faced with the almost impossible task of absorbing a large number of new aircraft over a period of a few months.

TYPE SELECTION

With this somewhat irrelevant aside, let me return to the matter of fleet planning, it being remembered that a decision had been taken for three basic types, all turbine powered, and that the company's route pattern covers a wide range of route distances.

The Short Range Aircraft

The short to medium range type selection was made in 1953 in favour of the Viscount, which came into service in the spring of 1955 as the first turbine propeller aircraft to be operated in North America. At the present time, we have 29 of them and 22 more will be delivered to TCA in the next seventeen months.

The Long Range Aircraft

Early in 1956 the company decided on the aircraft type which would be used on its extremely long routes, trans-Atlantic and non-stop transcontinental. In this case, the decision was somewhat simplified by the fact that the number of eligible aircraft and powerplants was comparatively small.

After a detailed study which took into account the specific requirements of the routes over which TCA intended to operate its long range aircraft, a decision was taken in favour of the Douglas DC-8 powered with Rolls-Royce Conway turbojet bypass engines.

The Middle Aircraft

At this point, TCA was committed to its shortest and longest range aircraft types, but there still remained to be taken possibly the most important decision of all, that of the type which would be used on the large number of routes, which, for want of a better name, have been called medium length, that is up to 1,700 miles.

In this case, not less than ten aircraft types were in the running with, as might be expected, a considerable variation in capacity, speed and range.

It at once became obvious that a selection of this middle aircraft type could not be made by regarding the problem as an isolated one. For example, the middle aircraft need not be capable of flying 1,700 miles if the number of DC-8's to be purchased was increased to make possible their operation over those routes as well as the routes of extreme length.

Similarly, the middle aircraft need not be capable of economical operation over routes as short as 350 miles, if the Viscount fleet was increased in size to cover all such routes.

Therefore, the middle aircraft study had to be extended in scope so as to cover the whole fleet pattern and each eligible aircraft type had to be economically tested in the light of varying fleet sizes of both Viscounts and DC-8's. This monumental task took over two years of hard and exacting work involving each of the four major functional departments of the company.

The result was a decision for the middle aircraft in favour of the Vickers Vanguard powered with the Rolls-Royce turbine propeller Tyne engine.

The Viscount

The related delivery programme is as follows:

Early 1958–18 Viscounts in addition to the 29 now in service
Early 1959–4 Viscounts
Early 1960–4 Douglas DC-8's
Early 1961–20 Vanguards
Late 1961–2 DC-8's

Governing factors

It might be argued that one modern aircraft is sufficiently like another to hardly justify the care and work which has been expended in this matter of type selection. Anyone holding such an opinion need, I think, only be told that implementing the aircraft purchase programme which has been outlined, involved committing the company to expenditures of $140,000,000 and, as taxpayers, you will agree that where an investment of this magnitude is involved, no amount of investigation and study is too great.

By the same token, considering the very small margin of profit at which all airlines must operate, it is essential, entirely apart from the capital investment, that the operating cost per seat-mile be as low as can be achieved in the light of the standards of safety, speed and comfort which must be met.

While I have carefully avoided naming what I may term the unsuccessful candidates in our studies of both airframes and engines, many of these will be known to you, and I therefore think it only fair to again point out that a TCA selection is based on this company's specific requirement for a group of routes involving considerations of distance, airport altitudes and temperatures, traffic volume, prevailing winds, and a host of other factors, all of which vary widely between one airline and another. It would therefore be quite wrong to generalize as to the relative merits of different aircraft or engines on the basis of TCA's selection. If I may use a far-fetched example, you might express a preference for a Rolls-Royce automobile as compared with a jeep, but your decision might be reversed if you were told that the use to which the vehicle was to be put was to plow snow out of driveways.

VISCOUNT

You may be interested in a few of the fundamental characteristics of the three aircraft types selected.

The Viscount most of you well know by personal experience. It fulfills the promise of the whole turbine powered family of aircraft by being reliable, fast, comfortable and economical to operate.

TCA's experience with this aircraft, which now exceeds 2½ years, has been extremely satisfactory. Its passenger appeal has exceeded our most optimistic estimates, with the result that the original order for 15 aircraft has in successive stages been increased to 51, while its operating cost is 9% below our original calculation made in 1953. Carrying substantial charges for depreciation, its cost per seat-mile is still less than larger aircraft which have been fully depreciated.

Its Dart turbine propeller engines have now reached 1,500 hours between scheduled overhauls, and may well reach the extremely long interval of 2,000 hours. These aircraft cost slightly more than $1,000,000 apiece, laid down in Canada, purchase tax paid.

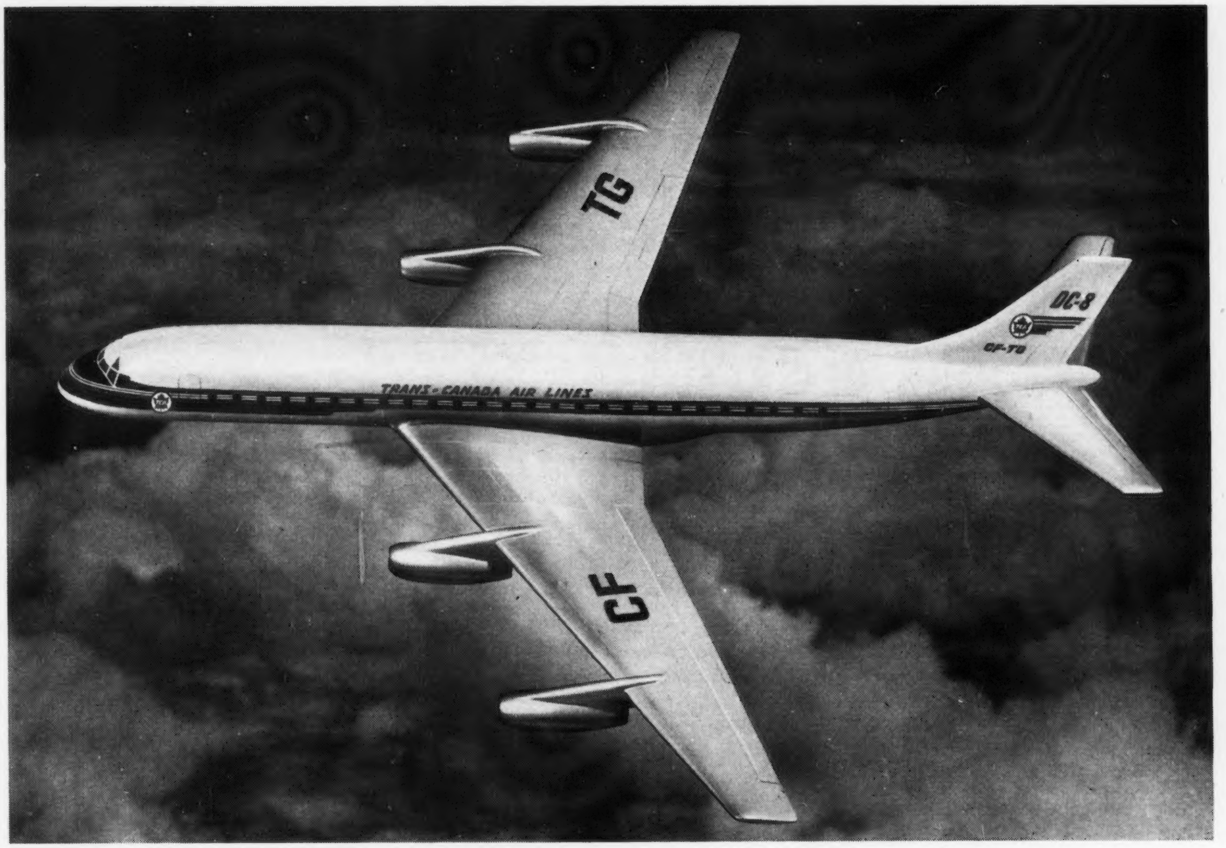
VANGUARD

The Vanguard, which is scheduled to take to the air for the first time in 1959, is a large, fast four-engined turbine propeller aircraft capable of a cruising speed of 420 mph, seating in great comfort 107 passengers, and having a range of 3,250 miles. This is not a big brother to a Viscount. It is a completely new design, both as to airframe and engines, but it will have all the desirable features of the Viscount, coupled with a greatly increased range and carrying capacity.

DC-8

The characteristics of the Douglas DC-8 produce its most efficient operation, as I have said, on long non-stop flights; it will cruise at 550 mph, carry 125 passengers,

The Vanguard



The DC-8

and it will have a still air range of 5,500 statute miles. Under normal conditions of wind, it will fly from Montreal to London in 6 hours. Due to its speed and size, in transportation capacity one DC-8 represents slightly more than 3½ Super Constellations.

If the cost of the ingredients of the product do not rise too greatly, the operating cost per seat-mile of the DC-8 should be about one-third less than that of any of the large piston engined aircraft now in trans-Atlantic service.

However this paragon among aircraft has certain drawbacks. Per copy, they will cost somewhat less, but not much less, than $6,000,000, and after a full refuelling they will have swallowed 18,000 Imperial gallons, which in flight they will consume at the rate of 1,700 gallons per hour. In this connection it is interesting to remember that a gallon of the fuel used weighs slightly more than seven pounds, so that a DC-8 with full tanks has a matter of sixty-three short tons of fuel on board.

PROGRESS AND CONSOLIDATION

In conclusion, may I provide you with a brief summary of what we believe will be produced by the full implementation of present plans.

(1) Aircraft fares over the past ten years, unlike virtually every other commodity, have on the average slightly decreased. All our calculations, reinforced by the actual experience of the Viscount operation, point to improved economy of operation with turbine power.

By late 1961, TCA plans to be operating only turbine powered aircraft and, incidentally, on the basis of orders now placed, it will be the first airline in the world to achieve that position.

Therefore, while there is still an expensive transition period to weather, with the further stipulation that to make the forecast hold good traffic volumes must continue to grow, I feel justified in prophesying that the cost of air travel in the turbine era will be no more than, and probably less than, it is today.

(2) That on the long routes it will be considerably faster, and on the very long routes much faster, than at present.

(3) Furthermore, in spite of many prophecies to the contrary, I believe the whole of the 1960's will be a period of what I might call "content" with subsonic speeds.

If this occurs, it will provide the airlines with a degree of financial stability which will never be theirs unless there is a slow-down in the rate at which civil aircraft become obsolete, not physically, but in passenger appeal.

WHEN IS AN AIRCRAFT A NUISANCE IN THE EYES OF THE LAW?†

by A. R. Paterson*

Blake, Cassels & Graydon

INTRODUCTION

I WAS deeply honoured when the organizing committee invited me to talk to you today but I was at a loss for a subject of interest to you which we could discuss together. I asked myself if indeed there were any subjects relating to aviation about which this audience would not know far more than I. However, after much correspondence with my old friend and school fellow, the indefatigable secretary of the Canadian Aeronautical Institute, Charles Luttman, I decided to discuss briefly the law of nuisance as it may affect the operation of aircraft. I hope it may prove to be of interest to you.

I think it is true to say there is considerable public anxiety that when the new multi-jet civil airliners now in production come into operation and when the air forces start operating some of the larger multi-jet bombers and new jet fighters, the noise that those machines will make may be, to borrow a word beloved of Hollywood 'blurb' writers, 'horrific'.

Whether that is a reasonable apprehension I cannot say, but I suspect that you gentlemen are able to make a realistic appraisal of the position. I would suppose that many of you in this room have had to consider this problem, whether as a manufacturer of civil or military aircraft or as an airline operator or as a government official. It may be that in your opinion the problem is already licked and that, as a result of current research, by the time new aircraft are in service, far from causing a nuisance to those who live near airports, the noise of their taking off and landing will be welcomed as inducing soothing sleep with sounds reminiscent of the purr of a contented cat or the hum of one of Mr. Hoover's products!

If the problem is beaten, both on civil and military jet engine aircraft, then I must apologize for wasting your time in discussing matters which would then only be of theoretical interest.

For the purposes of our discussions today, therefore, I propose to assume that no complete and satisfactory answer will have been found by the time the new aircraft come into service in substantial numbers and that both the volume and frequency range of the noise emanating from those aircraft, particularly during ground running and takeoff but also in flight and in landing, will be substantially more unpleasing to the human ear than that of the piston engine generally in use today.

SUMMARY OF THE LAW OF NUISANCE

I want to spend a few minutes in a brief discussion of the law of nuisance. Nuisances are of two kinds, public or common nuisances and private nuisances.

Public Nuisance

A public or common nuisance is a nuisance which affects the public at large. In England around the year 1765 public or common nuisances were said to be "... such inconvenient or troublesome offences as annoy the whole community in general and not merely some particular person."[a]

The public nuisances of that time included such things as " . . . the keeping of hogs in any city or market town"; "all disorderly inns or alehouses, bawdy houses, gaming houses, stage plays unlicensed, booths and stages for rope dancers, mountebanks and the like . . . "; lotteries; cottages " . . . if erected singly on the waste . . . ", that is to say on the waste or common lands. The reason for that being, of course, that they were likely to become harbours for highwaymen, "thieves and other idle and dissolute persons." "The making and filling of fireworks and squibs or throwing them about in any street . . ." was also a public nuisance as were "eavesdroppers or such as listen under walls or windows or the eaves of a house to harken after discourse and thereupon to frame slanderous and mischievous tales . . ." Lastly, the common scold was a public nuisance to her neighbourhood.

The remedy for a public nuisance is indictment, that is to say, it is treated as a crime. You will remember, for example, that in the case of the scold the law required that she should be sentenced to be placed in a certain engine of correction called the trebucket, castigatory or cucking stool, which in the Saxon language signified the scolding stool, although it was frequently corrupted into ducking stool because the residue of the judgment is that when so placed there, she shall be plunged in the water for her punishment. I have always felt that it was grossly unfair that the law only recognized a common scold to be of the feminine gender.

†Paper read at the Joint I.A.S./C.A.I. Meeting in Montreal on the 22nd October, 1957.

*Solicitor.

[a]Sir William Blackstone's Commentaries on the Law of England (1765) Vo. IV c. 13, p. 167.

No private citizen can sue in respect of a public nuisance unless he can show that it has caused him damage beyond that which he suffers in common with the rest of the public.

Since the days of Blackstone, there has been a huge addition to the list of public or common nuisances, created by statutes – especially in the domain of public health, and this will continue to grow – for instance, legislation with regard to pollution by smoke. An example of present day public or common nuisance which is of more interest to us might be the summer cottager who, without proper authority, runs a hydro cable over water on which there is a public right of navigation and thereby impedes the passage of boats or the passage of aircraft.

It does not follow that just because a nuisance may affect a number of people that it thereby becomes a public nuisance.[b]

If the operation of an airport or of an aircraft should constitute a menace, it is far more likely that any steps taken to try and stop it will be those appropriate in respect of a private nuisance and I think we can therefore, for the purposes of this discussion, forget public nuisances.

Private nuisance

Private nuisance has been defined as "anything done to the hurt or annoyance of the land, tenements or hereditaments of another and not amounting to a trespass."[c] That is to say a private nuisance is a disturbance of a man's rights of property, so the only person who can complain is the owner or occupier of property and he can do so not as a mere individual but as a man who has a right to moderate quiet and unpolluted air in the enjoyment of his property.

The second requirement is that the complainant must establish that damage has been suffered but if the court finds that his right to moderate quiet in which to enjoy his property has been substantially interfered with, then the law is ready to imply damage from the mere infringement of the right. He does not need to show any physical damage to the property or to himself.

Private nuisances usually arise from noise or vibration or air pollution. It is for the court, and in many cases this will mean a jury, to decide whether the nuisance complained of has in fact seriously interfered with the complainant's enjoyment of his property. If physical damage to the property can be established, then the complainant's task is much easier. If, however, the nuisance of which he complains merely affects his comfort and enjoyment of his property, then, in the words of an English judge in 1865, the law requires that for it to be actionable, it shall amount to "an inconvenience materially interfering with the ordinary comfort, physically of human existence, not merely according to the elegant or dainty modes and habits of living, but according to the plain and sober and simple notions among the English people."[d]

[b]Per Vice-Chancellor Kindersley in Soltau v. De Held (1851) 2 Sim (N.S.) 133.

[c]Stephens Commentaries (1st ed.) Vol. III, 499.

[d]Per Vice-Chancellor Knight-Bruce in Walker v. Selfe (1851) 20 L. J. ch. 433.

In this class of nuisance then, that is to say nuisance to comfort and enjoyment of property, the nature of the locality in which the property is situate becomes important. A Lord Chancellor of England said in 1904 "A dweller in towns cannot expect to have as pure air, as free from smoke, smell and noise as if he lived in the country, and distant from other dwellings, and yet an excess of smoke, smell and noise may give cause of action but in each of such cases, it becomes a question of degree and the question is in each case, whether it amounts to a nuisance which will give a right of action."[e]

The law also recognizes that there must be reasonable give and take. If your neighbour across the street is doing substantial alterations to his house and, in consequence, there is a certain amount of dust and noise, the court will not normally interfere unless of course he tries to carry on work all through the night or otherwise acts unreasonably. The philosophy behind this is that the day will come when you too may want to alter your house and that therefore there must be give-and-take. The law relating to private nuisance, therefore, often amounts to enforcing the "doing to others as we would they should do unto ourselves."

Whether or not the thing complained of is a nuisance has to be decided by the court as a matter of fact on the evidence and is as you can understand very largely a matter of degree.

DEFENCE

What defences are there to a claim for nuisance? First let me tell you a few things which are not a defence. Broadly speaking it is not a defence to show that a great many more people benefit from the continuance of the thing complained of than are annoyed by it,[f] but it would be unrealistic not to recognize that the court will probably hesitate to make a finding that the act complained of is a nuisance if it appreciates that substantial public hardship or inconvenience will result. Similarly the court may in such circumstances be less inclined to issue an injunction as this remedy is only granted at the court's discretion. The fact, therefore, that a large section of the general public might be gravely inconvenienced if an injunction were granted to stop all flying of certain types of aircraft from a particular airport, while only two or three people are suffering nuisance or annoyance from operation of these aircraft, does not, in theory at any rate, affect the position at all, although in practice it might tend to make the court hesitant about issuing an injunction.

Likewise it is not necessarily an answer that the complainant came to the nuisance.[g] The airport may have been miles in the country and operations continued merrily for years but that does not prevent a man who subsequently comes to live in the area from successfully maintaining an action if, of course, he can show that the operations do seriously interfere with his enjoyment of his property. Here again, however, I think one can fairly

[e]Per Lord Halsbury, Colls v. Home & Colonial Stores, 1904. A.C. 185.

[f]Per Lord Chancellor Hatherley in Attorney General v. Colney Hatch Lunatic Asylum (1868) L.R. 4 Ch. App. 146.

[g]Elliotson v. Feetham (1835) 2 Bing. N.C. 134. Bliss v. Hall (1838) 4 Bing N.C. 183.

say that the man who has come to a nuisance is likely to have a harder job to persuade the court to issue an injunction than the man whose peace and quiet has been subsequently invaded.

However, it is a defence to show that the appropriate legislature directed or authorized the doing of the particular thing complained of. This is equally so whether the thing which causes the damage is authorized for a public purpose or for private profit. Whether or not a statute authorizes the injury complained of is one of interpretation and in fact the courts construe the statutes very strictly. A general authority from a legislature to operate an airline would in no way authorize the commission of a nuisance. For a statute to justify a nuisance, the words used in the statute must be very clear and express in authorizing the act complained of and there must be no way of carrying out the directions of the statute without committing a nuisance.

For example, a society was incorporated by an act of a legislature for the express purpose of providing hospitals for the reception of the sick and poor. The society proceeded to erect a smallpox hospital which was held to constitute a nuisance to the occupiers of adjoining property and the court held that the statute authorizing the provision of hospitals could not be set up as a defence to an action for nuisance.[h] Had the statute expressly required the society to erect the smallpox hospital on that particular site, however, then the statute might well have been a defence to an action for nuisance.

THE POSITION IN CANADA

So far as aircraft are concerned, there are no statutes in existence in Canada of which I am aware which could conceivably be a defence if a court were to hold that the noise of aircraft landing or taking off from a particular airport, running up thereon or flying in a particular approach pattern, was a nuisance actionable by adjoining property owners.

As you can readily imagine, damages are often inadequate compensation for the infringement of the right to quiet enjoyment. What the property owner mainly wants is to prevent a continuance of the interference with his enjoyment of his property. Injunctions are entirely at the discretion of the court and are normally granted where damages would not be adequate. The circumstances which I am visualizing are that the noise of these aircraft will cause substantially more annoyance than anything experienced to date and if in such circumstances it is held that a nuisance has been committed, I would certainly expect a court to grant an injunction.

Everything that I have been saying so far is just a general statement of the Common Law of England which is the basis of the law in all of the Provinces of Canada except Quebec which has the Code Civile. The Code Civile is akin to the Code Napoléon. I believe that the principles of the English Common Law form the basis of law in many of the States of the U.S.A. You will have gathered from all that I have said that there is, of course, nothing to prevent the appropriate legislature from authorizing the commission of a nuisance or taking away a right of action in nuisance against the owners or operators of aircraft or airports. In Canada we have no

[h]Metropolitan Asylum District v. Hill 1881 6 App. Cas. 193.

such legislation and the position today is that if a property owner or property owners could satisfy a court that the right to quiet enjoyment of their property was being sensibly interfered with by the operation of an airport, or by operation of particular types of aircraft, damages would be recoverable and in all probability an injunction would be granted. In my opinion this is not a fanciful state of affairs and it is a possibility that I think calls for the most careful consideration both by manufacturers of aircraft and by operators of aircraft in and into Canada and, of course, of the Canadian government.

THE POSITION IN THE U.S.A.

I am not qualified to speak as to the position in the U.S.A. but, after consultation with those who should know about these matters, I understand that the position may be as follows. I say "may be" because cases are currently being litigated on the west coast and in New Jersey which should clarify the law of nuisance in its application to the operation of aircraft and airports.

You will, no doubt, be aware that there has already been extensive litigation in connection with Idlewild.[i] The Village of Cedarhurst, N.Y., which is some 4,000 ft from the eastern end of the airport, passed an ordinance prohibiting flying over the Village at a height of less than 1,000 ft and its right to do so was challenged. The judgment of the Second Circuit Court of the United States Court of Appeals was rendered last December.

This judgment establishes that Congress has pre-empted the entire field of regulation of air commerce, has legalized all flight within the navigable air space and has delegated to the Civil Aeronautics Board and the Administrator of Civil Aeronautics the establishment and enforcement of a comprehensive scheme of control over flight. It therefore declared the ordinance to be invalid. The allegations in that case related only to trespass but I am advised that the reasoning in the Cedarhurst judgment is equally apt to allegations of nuisance.

Some of my American friends in the eastern United States feel reasonably confident that the law now is that so long as an aircraft operator is doing what is required of him by C.A.B. regulations he will not be liable for damages nor can an injunction or prohibition be granted to restrain his operations.

Other American friends on the west coast are not at all sure that the fact that Congress has pre-empted the field of air commerce means that provided C.A.B. regulations are complied with the landowner can have no right of action in nuisance.

The Cedarhurst case did not determine this point as the claims by local landowners for nuisance were not proceeded with and the only point was whether the Village ordinance was valid.

My same optimistic friends in the eastern United States say that since the C.A.B. so closely controls aircraft operation – it prescribes routes, heights to fly etc. – and as any interference is prescribed it may be that the operator could successfully plead these facts as a defence. This would be analogous to the defence of statutory authority to which I have referred earlier.

[i]The Cedarhurst Case – Allegheny Airlines Inc. et al v. C.A.B. and Village of Cedarhurst et al 1956 U.S. & C.AVR 327.

My only comment is that if they are right then the courts in the United States must be a good deal less strict than the courts of England and I believe of Canada with regard to the essential requirements necessary to establish a defence of statutory authority.

It may, therefore, be that in the U.S.A. the aggrieved property owner has no redress against legal operation of aircraft or airports. However, if the trespass or nuisance became so intense and continuous as virtually to amount to a taking of his property, then he could bring an action for compulsory taking without compensation but such an action could only be against the U.S. Government, a municipality or other authority having a statutory right to take land.

Assuming that the landowner has been deprived by Congress of any right of action where the C.A.B. regulations are complied with, what is the position if the aircraft operator commits the nuisance or trespass while violating C.A.B. regulations? Will an action lie? Possibly — but probably not unless the alleged violation has been brought before the Board and established as a violation.

If therefore the Cedarhurst case does all the things the optimists claim for it, then it looks as though in the United States the aircraft operator who obeys all C.A.B. rules and regulations is immune from successful attack and that the airport operator is in much the same happy position unless operations for which it is responsible amount to a "taking" of property without proper compensation.

I think however for the moment it may be safer to say that it is not yet established beyond doubt that the landowner in the United States can never be successful in an action for nuisance against the operator of aircraft, even where the C.A.B. regulations are fully complied with. The position is likely to be clarified in the two pending cases I have already mentioned.

THE POSITION IN THE UNITED KINGDOM

So far as the United Kingdom is concerned, the common law has already been substantially altered by statute, possibly because it is a very small densely populated island and the problem of aircraft noise as a nuisance is a very real one which had to be faced many years ago.

Since 1920 there has been legislation providing that "no action shall lie in respect of trespass or in respect of nuisance by reason only of the flight of an aircraft over any property at a height above the ground which having regard to wind, weather and all the circumstances of the case is reasonable or the ordinary incidence of such flight so long as . . ."[j] certain provisions are complied with.

Those provisions are contained in the Air Regulations and are similar to the Air Regulations in force in Canada and, I assume, in the U.S.A.

As you can see, this covers ordinary flight, takeoff and landing, provided that the aircraft is being operated reasonably and properly. You will have also observed that it only covers the position when the aircraft is in flight, that is to say when it is airborne and it does not deal with that part of the takeoff or landing when the aircraft is not airborne nor does it cover taxiing, running up etc.

Largely I think with the development of the De Havilland Comet, the problem of noise emanating from airports became acute very soon after the war and since 1947 legislation has been in force in the U.K. which provides that "no action shall lie in respect of nuisance by reason only of the noise and vibration caused by aircraft on . . ."[k] certain specified aerodromes provided that certain conditions are complied with. The aerodromes are prescribed by Order-in-council and the British Minister of Transport and Civil Aviation is empowered to "prescribe the conditions under which noise and vibration may be caused by aircraft (including military aircraft) on government aerodromes, licensed aerodromes or aerodromes at which the manufacture, repair or maintenance of aircraft is carried out by persons carrying on business as manufacturers or repairers of aircraft . . ."[l]

The Minister in turn has laid down certain regulations which provide that ". . . the conditions under which noise and vibration may be caused by aircraft . . . on . . . aerodromes . . . shall be as follows, that is to say that whether in the course of the manufacture of the aircraft or otherwise:

(a) The aircraft is taking off or landing.

(b) The aircraft is moving on the ground or on water or,

(c) The engines are being operated in the aircraft,

  (i) For the purpose of ensuring their satisfactory performance.

  (ii) For the purpose of bringing them to a proper temperature in preparation for or at the end of a flight or,

  (iii) For the purpose of ensuring that the instruments, accessories or other components of the aircraft are in a satisfactory condition.

and also such special conditions if any, as may be prescribed as respects any such aerodrome as aforesaid."[m]

As you can see, therefore, in the United Kingdom the problem has been put fairly and squarely in the lap of the Minister of Transport and Civil Aviation and he has to do his best to try and hold a balance between the public interest and private interest. Public interest presumably requires as little interference and interruption as possible with aircraft operating scheduled services, while private interest may perhaps stand for the right to reasonable quiet enjoyment by the owners of property liable to be affected.

In practice this system probably is more effective than one might think as the Minister can be kept on his toes by questions in Parliament, private letters from M.P.'s and the like to see that everything reasonably possible is done to mitigate the nuisance. It is some years since I have been at London Airport, but even then

[j]Air Navigation Act 1920 — re-enacted as Sec. 41(1) Civil Aviation Act 1949 (12 and 13 Geo. 6 c. 67).

[k]Re-enacted and now Sec. 41 Civil Aviation Act 1949 (12 and 13 Geo. 6. c. 67).

[l]Article 56, The Air Navigation Order 1954 (S.I.1954 No. 829).

[m]Regulation 230, The Air Navigation (General Regulations) 1954 S.I.1954 No. 925).

there were special baffle walls and special running up bays had been erected for the running up of jet aircraft in an endeavour to mitigate the nuisance.

CONCLUSION

I have now come to the end of my remarks and in concluding I would like to suggest that this problem is a real one and that unless one can be very sure that there is little chance of the new aircraft, when they are in service, being held to constitute a nuisance to the owners and occupiers of property adjoining airports, the aviation industry, both manufacturers and operators should, if they have not already done so, have discussions with the governments concerned and see what, if anything, can be done, pending the production of adequate mufflers, to give the owners and operators of airports or aircraft some reasonable measure of protection from actions for nuisance.

It is, of course, largely an international problem. The British appear to be the only people which have attempted so far to tackle the problem directly. If the Americans have dealt with it successfully, as the optimists contend, then they appear to have done so incidentally and accidentally.

If the problem has to be tackled – as I believe must be done in Canada, possibly also in the United States – is there merit in the way in which the British have tackled it? Even if the British method were to be adopted elsewhere, however, it is well to remember that if the problem became too acute the Minister or other authority might still feel obliged to restrict certain types of aircraft from using certain airports. A few weeks ago, in a written parliamentary answer to a question as to what action he proposed to take to prevent residential areas surrounding airports from being subjected to excessive noise from the large civil jet aircraft now being developed, the British Minister of Transport and Civil Aviation replied,

"The manufacturers and prospective operators of these aircraft must not underestimate the overriding importance of reduction in the volume of noise at source by the use of silencers and any other devices available."

I repeat that I believe that this is an urgent issue and that while no doubt every effort is being made to develop adequate mufflers, I think that both the manufacturers of aircraft and their customers, the operators, should have some very clear idea as to what can be done politically by legislation to bridge the gap until those mufflers are produced in the event of actions for nuisance being successful and injunctions or prohibitions being granted.

ANNUAL GENERAL MEETING

The Annual General Meeting of the Institute

will be held in the

KING EDWARD HOTEL

TORONTO

on the

26th and 27th May, 1958

The Programme, which is now being prepared, will include Sessions on

Engineering Administration, Production Engineering, Design and Application of Computers, Ground Support Equipment, STOL and VTOL

as well as the annual Business Meeting.

This meeting affords an opportunity for the presentation of papers by members of the C.A.I. The Council is most anxious to encourage Canadian papers and hopes that any member wishing to contribute to any of the above-mentioned Sessions will submit a summary of his paper for consideration. Such summaries must be in the hands of the Secretary by the 31st December 1957.

NOISE RESEARCH IN THE UNITED KINGDOM†

by Professor E. J. Richards*

University of Southampton

INTRODUCTION

WHILE you have given me great pleasure and the honour of describing the work being carried out in the United Kingdom on the noise problem, nevertheless, I am faced with grave misgivings lest on the one hand the paper deteriorates into a dull cataloguing of individual efforts or, on the other, presents a completely inadequate description of the scientific merit of the various researches and their place in the general picture. This is made more than ever difficult because of the highly unusual framework of noise research in the United Kingdom and the absence of any single large group of researchers coordinating the country's research effort. Indeed, it is a significant indication of the size of the country's effort that my own research school at the University of Southampton, fourteen strong, is by far the largest unit working on the problem.

This situation has resulted chiefly from the pressure on Government research circles to concentrate, and rightly so, on problems directly concerned with the efficiency of the next breed of aircraft, engines and guided missiles. The Ministry of Supply has consequently, by the placement of outside contracts, left the problem of noise suppression to aircraft engine firms and the Universities, the former to establish ad hoc devices, the latter to study the phenomenon fundamentally and to set up a sound framework of knowledge in this new science. Recently the aeroplane structure as well as the public has begun to object to the disturbances arising from jets, with the result that investigations are now being initiated in many airframe firms into the effects of noise on structural fatigue. Thus, in the relatively short period of seven years, we can list the various aspects of the problem in a manner which categorizes not only the fundamental problems, but also the various research groups working in the field. For convenience, let me list these aspects as follows:

(1) The establishment of the problem,
(2) The study of jet noise at source,
(3) The suppression of jet noise,
(4) The effect of noise on structures,
(5) Boundary layer noise,
(6) Propeller and helicopter noise.

†Paper read at the Annual General Meeting of the C.A.I. in Ottawa on the 28th May, 1957.
*Professor of Aeronautical Engineering.

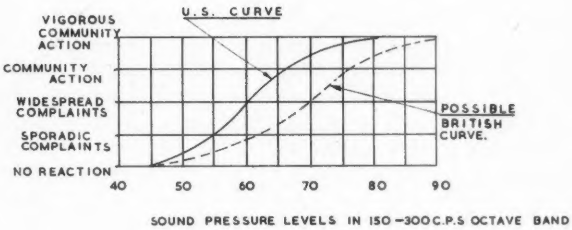


Figure 1
Human response to noise

THE PROBLEM

The first of these, establishing a true indication of the seriousness of the problem, both from the ear damage and community reaction point of view, has probably been the least studied in the United Kingdom, the vast wealth of medical and community response experience now being obtained in the USA being used extensively by our planners. While ear damage laws are not likely to alter from country to country, the means available to the community of showing their annoyance does differ appreciably. For example, while a community in the USA can obtain an order to prevent aircraft flying in their vicinity, an Order in Council debars such a happening in the United Kingdom and other more round about methods, such as a "question in the House of Commons", have to be resorted to.

An analysis of complaints has been going on recently, however, which does shed some light on the differences of community reaction country to country. Thus, although in houses and flats people's reactions agree quite closely with those in the USA, the onset of violent reaction to aircraft noise is delayed by one and probably two gradings of noise level compared with American reaction. This work is still proceeding[a] but it appears that the outcome will be to modify the USA community reaction curves[1] probably as shown in Figure 1 for noise in the 150-300 cps octave band, usually the worst one on jet engines. In addition to analyses of complaints, many noise measurements have been made at London Airport of modern aircraft flying overhead; for example,

[a]Work under the guidance of Dr. Bell of Ministry of Transport and Civil Aviation and D. M. A. Mercer of University of Southampton.

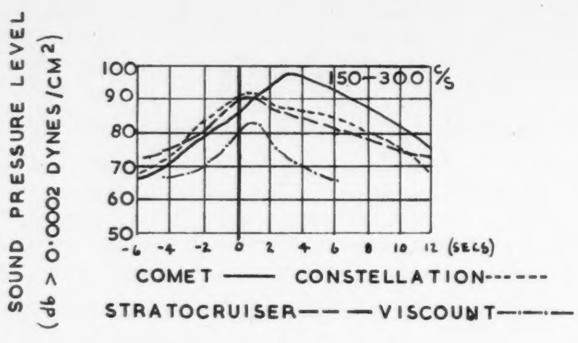


Figure 2
The noise of jet and propellered aircraft flying over London Airport at the same height

Greatrex[2] of Rolls-Royce uses the measurements of Figure 2 to suggest that the noise levels of contemporary British jet aircraft are only some 4 db higher than those of other well established piston engined types, and that the establishment of these latter for so long is ample indication of the inadequacy of the American reaction figures. This state of affairs in fact confirms the realness of the second curve of Figure 1; at the same time, the fact that these same aircraft have been accepted as commercial successes for so long in the USA, even though they lie in the category where numerous complaints must have been made, shows the highly contentious nature of such analyses and the need for each country to establish the magnitude of the problem.

We in the United Kingdom differ amongst ourselves as to the exact amount of nuisance being caused. From the scientific point of view, however, our aims are fairly clear, namely to obtain a reduction of some 10 to 15 db throughout the frequency range on the new jet airliners in flight and about 30 db reduction during ground running[3].

THE STUDY OF JET NOISE AT SOURCE

Subsonic jets

Until seven years ago, the mechansim of sound production from moving air had received practically no attention from the classical acousticians and the jet noise problem arose with few, if any, accepted theories for scientists to base their thoughts. Quite quickly, however, Professor Lighthill of Manchester University filled this void with a theory[4] of aerodynamic noise which has already become a classic in the new field of science. In it, he relates for the first time the acoustic radiation from the jet with a function of the turbulence of the jet as it mixed with the surrounding medium. Thus, if the aerodynamics of jet mixing and its variation with time were known, the sound output could be calculated exactly. He shows that the intensity of the sound depends on the field of acoustic quadrupoles of strength equal to that of the stress tensor T_{ij} integrated over the whole field of turbulence[4]. This stress tensor is unfortunately completely unknown in a jet, though the dimensional variations can be obtained by inspection. Lighthill has nevertheless put forward interesting and useful relationships which establish the relevant parameters. Since much of the work in the United Kingdom is based on this theory, it is worthwhile to list the significant points:

(1) He shows that the noise is that from a field of quadrupoles. Since the majority of the energy is used up in near field reciprocation, the radiated energy is very much a function of the frequency of disturbances and varies as frequency to the sixth power. Since in a jet it is reasonable to assume that the frequency will depend on the speed of convection downstream of the burbles of turbulence, which in turn depend on the speed of the jet, the total energy radiated will vary as the kinetic-energy $\times$ V^6, i.e. as V^8. This is the basis of the so-called "eighth power law".

(2) More accurately, he relates the noise of $\rho V^3 d^2 \times M^5$ where $\rho V^3 d^2$ is a measure of the horsepower of the jet and M is the Mach number relative to the speed of sound in the undisturbed medium.

(3) He explains the directionality found in the various frequency ranges. As many observers have now established, the high frequency noise from a jet is highly directional with its maxima occurring downstream at an angle of 30° to the jet and with smaller maxima upstream (Figure 3). It is generated chiefly by the turbulence near to the nozzle and, as would be expected from the theory, is accentuated by the sharp velocity shear in this region. Further downstream the velocity shear is much smaller, the turbulence is of larger scale and gives rise to almost a radial field of low frequency noise.

The best experimental verification of Lighthill's theory carried out in the United Kingdom is that of Gerrard[5] at Manchester, who shows that the general character of the noise field confirms that predicted by

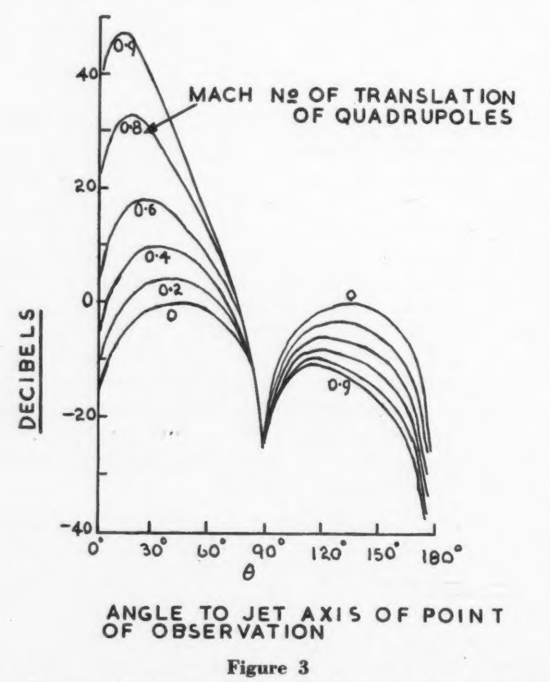


Figure 3
The directional variation in sound field from a single lateral quadrupole for various Mach numbers of quadrupole translation downstream

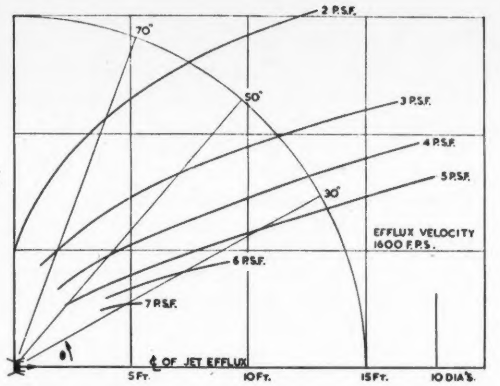


Figure 4

Constant overall sound pressure contours. Obtained from starboard outer engine (Ghost 50) on Comet G-ALYS

Lighthill; he traces the directivity pattern back to the source and indicates that the low frequency sound comes from the turbulence in the centre of the jet at a distance downstream where the velocity shear is low and spread over a good length of the jet. He suggests that, owing to Doppler effect on the moving eddies, sources of different "source frequency" may radiate the same noise frequency. This adds greatly to the difficulty of assessing the source position with any accuracy. As other experimenters have found, the high frequency noise emanates from the high velocity shear region fairly near the jet nozzle and is amplified by this.

Gerrard shows that the power index for intensity M^n varies as much as by 4 from the forward to aft position, as indicated by Lighthill for the more highly moving sources (i.e. high frequency noise). This general finding that the eighth power law varies considerably with the position around the jet is also confirmed by Wolfe[6], who has measured (Figure 4) the acoustic pressures in the vicinity of the Comet. The indices appertaining around the jet engine (Figure 5) show a similar variation on an actual full-scale hot jet. Hetzel[7] in noise measurements around a full-scale jet similarly confirms this variation. Thus the outcome of these experiments is to show that qualitatively noise is caused by turbulence in the manner outlined by the theory but that until a detailed study of the aerodynamics of the jet is made, little further can be obtained from it. Bearing in mind the fact that it is only 0.01% of the turbulent energy that is radiated acoustically, the immensity of

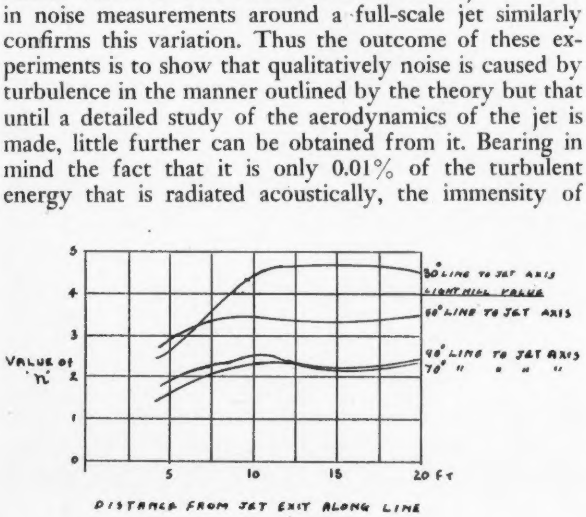


Figure 5

The variation of the index for $\bar{p} \propto V^n$ with position around the jet

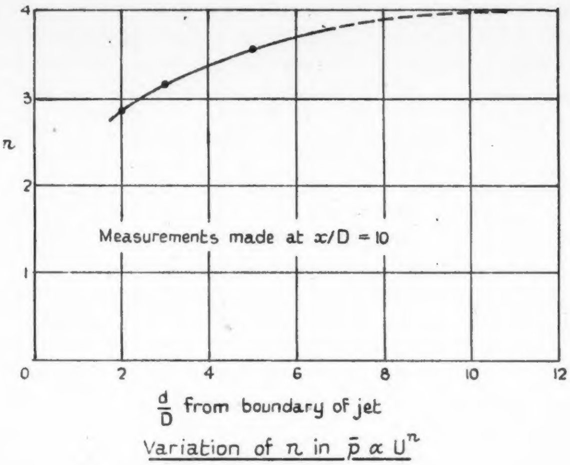


Figure 6

The variation of the index n for pressure amplitude $\bar{p}$ at distances d from the jet

the task of correlating in detail the noise output with the turbulence in the jet is apparent to all.

In simple terms then, our problem is this; all the energy in the jet is eventually transformed into turbulence and this will involve pressure fluctuations in the mixing region clearly related to $\frac{1}{2}\rho V^2$. This turbulence will disturb the surrounding air and an induced flow field will occur. This induced fluctuating flow will be partly hydrodynamic in which pressure and velocity are out of phase and no energy radiation occurs. The other smaller part will consist of pressures and velocities in phase resulting in radiation of energy outwards. As the distance from the disturbance is increased, this latter will predominate, energy being propagated as sound waves. Thus in any measurements, or in any explanation, we must differentiate between the jet flow itself, the non-radiated field in the near vicinity and the radiated field at some distance away, all of which give rise to pressure fluctuations but only a little of which is transmitted as sound. The near field will clearly be very significant when the problem of structural excitation is in question. Franklin[8] at Southampton has recently analyzed measurements with this in view, Figure 6 giving the variation of the index of the pressure variation with velocity. As would be expected, the rms pressure amplitude close the jet varies as the velocity squared, while at a distance of ten diameters the index rises to 4, the value expected with pure acoustic radiation. This, of course, corresponds to an index of eight on energy transmission, i.e. sound intensity.

In view of the above, it is clearly very difficult to know where to start in any build up of knowledge of noise creation; the only really acceptable method is to obtain a full knowledge of the instantaneous values of the turbulence and to use it in Lighthill's theory which then can be made to cover both the near and far field of aerodynamic flow. So far in the United Kingdom preliminary examinations have been only to establish the elementary nature of the turbulence in a jet, cross correlation terms of the type $\overline{uv}$ being left until later. The development of a technique is crucial in this context; hot wire anemometer development is being carried out

by Wise and Schultz[9] at Oxford, Doak at Manchester and by Leahy at Southampton. Difficulties arise over and above those in wind tunnel turbulence techniques, because very high frequencies are involved on model jets (and consequently very thin wires) and fluctuations about the mean are very much larger than in wind tunnel work. Leahy has studied these very thoroughly and has concluded that the constant velocity method of Ossofsky[10] is the most suitable. On the basis of this, Williams at Southampton is carrying out measurements of turbulence on both a circular and corrugated jet at subsonic speeds. As yet it is too early to draw any conclusions from this work. The difficulties involved emphasize once again the enormous need for new and satisfactory methods of measuring turbulence in highly fluctuating airstreams.

Choked jets

Once the flow in the jet has reached its critical pressure ratio (i.e. that pressure ratio which produces sonic flow in the jet pipe at its point of minimum area), the aerodynamic structure of the jet depends crucially upon its nozzle shape. For a convergent-divergent nozzle of the correct area variation, the jet pressure may be brought to the outside pressure with shock free flow; the jet is then said to be correctly expanded. For larger (over-expanded) or smaller (under-expanded) outlet areas, the ensuing jet will contain shock waves; these shock waves are responsible for a considerable amount of the noise output of the jet as a result of eddy-shock wave interaction.

The first experimental indication of the possible mechanism of such noise formation was reported by Powell[11] at the ASA noise conference at San Diego in 1952. A description of the subsequent United Kingdom investigations, both experimental and theoretical, fall effectively into four parts:

(1) An examination of the phenomenon of resonance in choked jets and the frequency of the sound emission.

(2) An experimental and theoretical study of the interaction between a shock wave and an eddy in the form of a discrete vortex, in order to establish the nature of the sound wave emitted and to assess its dependence upon the parameters of shock strength and velocity perturbation.

(3) Noise measurements on cold jets using convergent-divergent nozzles.

(4) An analysis of the effect of temperature fluctuations convected through a shock wave.

The photographs shown at the 1952 conference indicated the presence of discrete tones and this has been explained[12] in terms of a resonance mechanism. When an eddy moves downstream and interacts with a shock wave in the jet structure, a sound wave is produced which radiates into the surrounding atmosphere and has in particular an intense component in the upstream direction, i.e. towards the lip of the jet orifice. On meeting the lip of the orifice, a further eddy is liberated due to the fluctuating pressure and this eddy then causes a repeat of the original cycle, the continuous process leading to a regular liberation of sound waves of a discrete frequency. Powell explains this in terms of the cell spacing and jet velocity. The existence of such a note has also been confirmed by direct measurement[13] which shows the frequency of the note to be directly related to fluctuations in the jet stream.

Recently Davies[14] at Liverpool University has examined this phenomenon in more detail and explains the radiation field in terms of the cell spacing, radiation wavelength disturbance spacing and the position of the effective sources and their variations with jet pressure ratio. By treating the radiation as consisting of "pulses" from a number of primary sources, the photographed sound field is well reproduced. An interesting observation from the results is that Mach-Zeider interferometer measurements indicate that as much as 20% of the kinetic energy of the stream can be radiated in this way. This confirms the earlier Southampton work indicating a noise intensity against velocity index of as high as 26.

There is little indication that such a resonance occurs on full-scale jet engines where conditions at the nozzle are more confused and less likely to allow a resonance. Nevertheless, the single interaction between turbulence and a shock gives rise to much noise. Experiments have, therefore, been made by Hollingsworth[15] to examine photographically the interaction between the simplest "two-dimensional region of turbulence", i.e. a vortex, and a shock wave, with particular reference to the production of a sound wave. A shock wave was made to travel along the tube and then be reflected from the end of the closed low-pressure compartment. In passing along the tube, the shock traversed an aerofoil placed at some positive angle of incidence, a trailing vortex being formed in the relatively slow moving stream behind the shock.

A typical Schlieren photograph showing the sound wave emitted is given in Figure 7. The extraneous shocks to be seen result from reflections from the walls of various waves propagated at the aerofoil and end-plate and are difficult to eliminate with the technique used. They do not affect the general interaction pattern, however, which indicates clearly the way in which a sound wave is emitted, the greatest free sound output being

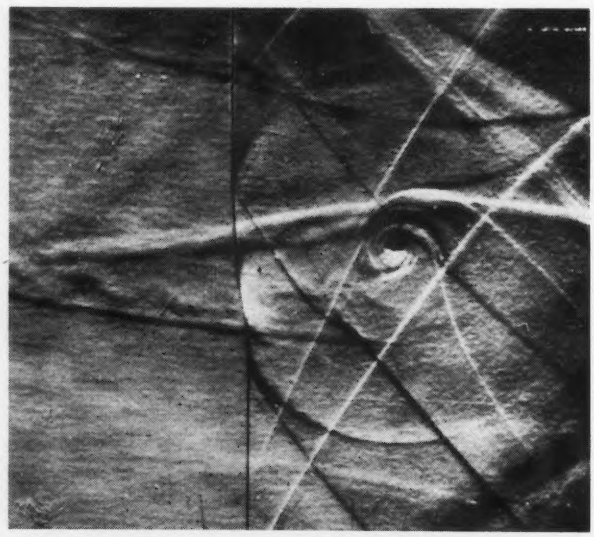


Figure 7

Photograph of the sound emitted from the interaction between an eddy and a shock wave. Note the circular compression and rarefaction wave concentric with the eddy

directed at angles towards the shock. The photographs, while being only of a qualitative nature, do nevertheless indicate two general trends which have since been confirmed theoretically, namely,

(i) The radiation downstream, away from the shock, is small compared with that upstream, and

(ii) The strength of the sound wave appears to depend largely on the strength of the vortex and less on the strength of the shock.

A theoretical treatment, based on work by Ribner, of the flow has been made[16] which, in fact, bears out the foregoing tentative conclusions. Although the method of analysis does not pretend to be analytically rigorous, the similarity between the theoretical pattern of sound emissions and that photographed in the shock tube experiments allows some conclusions to be drawn with a fair degree of confidence. The sound wave originating from the interaction is very intense, on an audio scale, for quite small vortex velocity perturbations; a mean sound level of 122 db is forecast for an 0.1% fluctuation about the mean velocity at $M = 2.0$. For these particular calculations, which refer to the conditions behind a shock in a wind tunnel with atmospheric stagnation conditions, the sound pressure amplitudes depend linearly on the strength of the vortex velocity perturbations, whereas the shock strength has less effect. Indeed, in this particular instance, the amplitude of the sound is reduced slightly as the Mach number forward of the shock increases above $M = 1.5$. It should be emphasized, however, that the emitted sound depends greatly on the steady flow conditions which prevail in the tunnel.

As a tentative conclusion, therefore, it may be stated that the noise emitted from the interaction between the turbulence in a jet and the standing shock pattern depends primarily on the strength of the turbulence and less on that of the shock conditions, save for very weak shocks. Thus, unless the jet nozzle has been designed correctly for exactly the operating conditions, even the existence of slight shocks in the jet flow will give rise to large emission from the interaction.

With this thought in mind, experiments have been done at Southampton[17] to examine the noise emitted from a series of convergent-divergent nozzles designed to give the correct expansions equivalent to $M = 1.1$, 1.2, 1.3, 1.4 and 1.5. The experiments were done on small models of 2 in diameter operating with cold air; consequently temperature effects were absent and the results have only limited application to full-scale jets. Nevertheless, the curves of overall noise levels so obtained are of great interest (Figure 8). These all refer to a point situated at a distance of 4 ft from the jet exit at an angle of 30° to the axis of the jet, normally the direction of greatest noise amplitude. It is seen that in every instance the overall noise level increases with the upstream stagnation pressure, except in the vicinity of the design pressure ratio, indicated on the curves by the Mach number arrow, where a definite dip is recorded. Taking the variation on the $M = 1.4$ nozzle, it may be seen that there is an overall reduction in intensity of 6 or 7 db at the station considered over that for a normal convergent nozzle. For pressure ratios above this, however, the reduction quickly disappears. At pressure ratios lower than the design figure, the noise is again similar

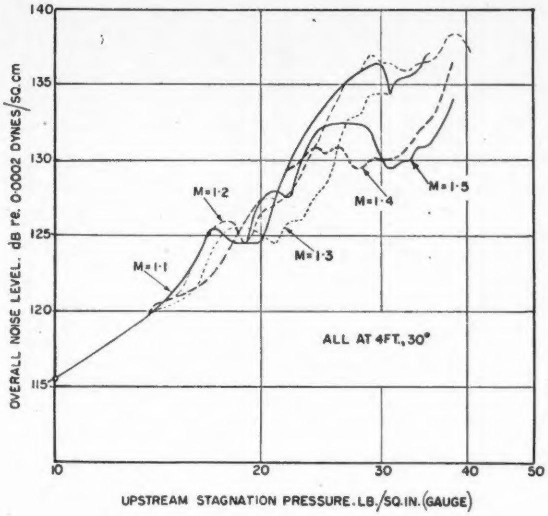


Figure 8

Overall noise level. Several convergent-divergent nozzles designed for different working pressure ratios

to that of the convergent nozzle, although at no stage is the noise greater and, sometimes, it is less. The main conclusion to be drawn is, therefore, closely associated with that of the shock tube experiments, namely, that an appreciable noise reduction can be obtained by using a convergent-divergent nozzle but that this reduction is confined to a small pressure ratio range around the correct ratio for that nozzle. Away from these conditions, the shock patterns are sufficiently strong to allow noise emission from their interaction with the turbulence passing downstream, this emission being a function of eddy rather than shock strength.

The more general case of the energy scattered when a sound wave passes through a turbulent fluid was studied by Lighthill[18] in 1952. Following this, Johannesen at Manchester is interested in making a detailed analysis of the pressure and turbulence in a supersonic jet and has recently reported his findings[19] for a round jet issuing at a Mach number of 1.5 into still air from a nozzle of roughly 1 in diameter. Because this jet has shock waves of appreciable strength present, preliminary work has gone into a more carefully designed nozzle which is found to be sensibly shock free. An interesting observation on this jet which ties up with the above is that there is a noticeable reduction of noise when it is operating at its design condition. Since the purpose of the work is primarily to examine the turbulent mixing of a supersonic stream, turbulence measurements are planned over a wide range of Mach number.

Turning finally to the effects of temperature fluctuations in the jet, essentially a separate item from the previous discussion, it must be remembered that only results of a qualitative, theoretical nature, involving the interaction of plane sound waves with a plane shock wave, have so far been established. Kovaznay has shown that perturbation in pressure, velocity, or temperature, gives rise to sound waves, temperature fluctuations and velocity fluctuations in the downstream flow after convection through a shock wave and this has been further verified

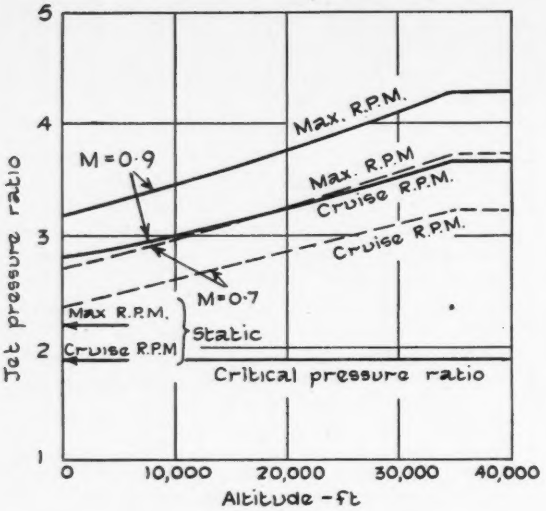


Figure 9
Typical jet pressure ratios at speed and altitude

by Powell[20], with particular reference to the production of sound waves. The laws appertaining to this noise in one dimensional flow have been written down in an attempt to establish the magnitude of this source of noise emission. In acoustic measures these fluctuations are capable of large noise emissions of a magnitude comparable with that due to turbulence. For example, if with a normal shock wave the upstream Mach number is 2.0 and the upstream conditions are atmospheric, a 0.1°C temperature fluctuation will result in a pressure amplitude corresponding to 126 db sound pressure level. It is clear, therefore, that temperature fluctuations are likely to be a source of considerable noise in choked jets of gas turbine engines, rockets and so on, in particular where poor combustion occurs. Experimental shock tube work has begun at Southampton on this interaction between a "hot spot" and a shock wave. Appleton has already photographed the reflected sound wave in the one dimensional case and intends to examine the wider aspects of rough burning during the next year.

From the above, it is clear that more fundamental work is proceeding in the United Kingdom in the field of choked jets than is occurring on subsonic units, in spite of their being of less importance to the main issue of noise during takeoff. However, as shown in Figure 9, even during takeoff, jets are mildly choked and will become more so as pressure ratios are increased. The reason for the emphasis stems, nevertheless, from the system of relying on the Universities. They naturally choose problems which are tractable, their importance in the general picture being of relatively little significance.

NOISE SUPPRESSION AT SOURCE

The fundamental understanding gained from the above studies must not be underestimated because of the vast detailed knowledge yet to be achieved. It leads immediately to the following methods of reducing the noise nuisance, all of which are being studied in the United Kingdom at the moment.

(1) By reducing the engine power (i.e. either by reducing maximum flying speed where possible or by reducing drag coefficients).
(2) By reducing the jet velocity (i.e. by using a larger jet with lower outlet velocity).
(3) By reorienting the initial climb plan and the ground test cells in the light of directivity patterns.
(4) By modifying the shape of the jet or using a series of jets.
(5) By using a well designed muffler during ground running.

Engine power

This varies as density × wing area × (velocity)^3 at subsonic speeds unless some special drag reducing invention, such as boundary layer suction, is invoked and increases similarly at supersonic speeds except in so far that the coefficient of drag has been increased by a factor of some 4 or 6. Thus, if the same jet emission Mach numbers are involved, i.e. the pressure ratio is not increased, the sound pressure level in decibel scale of the noise will increase by $30 \log_{10} V/V_0$ in increasing an aeroplane's speed from V_0 to V. Thus, an increase in speed from 400 to 500 mph on the same aeroplane involves a noise increase of approximately 3 db, which can make an appreciable difference to the noise nuisance; and an increase to 1,000 mph, i.e. to supersonic speeds in level flight, is going to involve a noise increase of $10 \log 4 + 30 \log 2.5$, i.e. 18 db. These figures assume, of course, that the full power is used during takeoff. They are, however, very strictly minimum increases and will in fact be higher, unless modern trends in increasing engine pressure ratios are halted. Those of us who have spent many years in studying the science of noise reduction know that, in practice, the need to commence noise suppression from a level 18 db higher than the present figure may well be representing a completely impossible task.

This should be made clear to the forward planners of supersonic airliners. In this context, we in the United Kingdom are most interested in the American figures[1] regarding the influence of repetitive noises on the acceptability curves. For example, the level of noise which is acceptable once an hour is more than 10 db higher than that if it occurs once a minute. This suggests that both designers and planners should only accept the need for very high powered jet airliners if the economic gain is really appreciable and that the demand for jet aircraft for medium distance high intensity routes should be rejected.

Jet velocity reduction

Since thrust depends on d^2V^2 while noise depends on d^2V^8 approximately, it is clearly advantageous to commence with a larger diameter jet pipe and a lower velocity of emission. Thus, for a given thrust, the noise pressure level varies as V^6 and a 10% reduction in velocity will give a noise reduction of 60 log 1.1 (i.e. $60 \times .04 = 2.4$ db) and a 20% reduction will give rise to nearly 5 db reduction. Such reductions in velocity have been obtained at the moment on one British engine, the Rolls-Royce Conway[2], by the use of the bypass principle. Figure 10 gives measurements of the total noise levels at a distance of 50 ft along the 30° angle position,

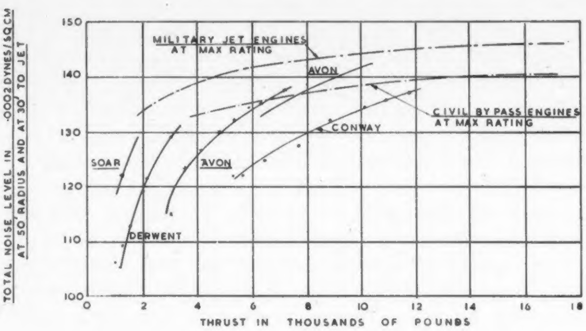


Figure 10
The effect of jet velocity on engine noise

roughly the direction of maximum noise. The dotted curves indicate the optimum difference to be expected by changing from a military engine to a civil bypass engine (both at maximum ratings) for various engine thrusts. A difference of some 6 db is apparent.

In effect, this engine is a step towards the ducted fan engine, a still better project from the noise point of view. It must be pointed out in fairness to other manufacturers that it is the lower velocity that is significant, of course, and not the principle of the bypass or ducted fan. Theoretically there should, however, be an additional gain from the bypass engine due to the distribution of velocity across the jet. As yet, however, this has not been established experimentally, the only results[21] obtained so far in the United Kingdom indicating no great gain from graduating the velocity distribution across the jet.

Modification of the shape of the jet

Since such a small proportion of the turbulent energy is radiated as sound, it is extremely difficult to associate noise reductions directly with changes in the turbulence distribution consequent upon the jet nozzle being changed in shape. Nevertheless, it was found some time ago[22] that relatively minor changes in the jet shape did, in fact, alter the radiation significantly and, as a result, a series of ad hoc experiments have been carried out to exploit this fact, chiefly by Greatrex at Rolls-Royce[23] and following them at Boeing in the USA[24]. Figure 11 shows the noise reduction at a typical point plotted against frequency for a whole series of corrugated nozzles. One particular design of corrugation at least has been examined thoroughly on four different engines at all points around them. The ratio of the total integrated acoustic power to the (relative density)^2 $\times$ the area is plotted in Figure 12 for a range of jet velocities. It is seen that an overall reduction of 5 db in total acoustic power is to be obtained by using relatively modest corrugations while more satisfactory gains are obtainable in the direction of maximum noise. Indeed, such corrugations have now been developed to the stage that it is the less spectacular reduction at 90° to the jet axis that is determining the level of noise received on the ground when an aircraft flies overhead.

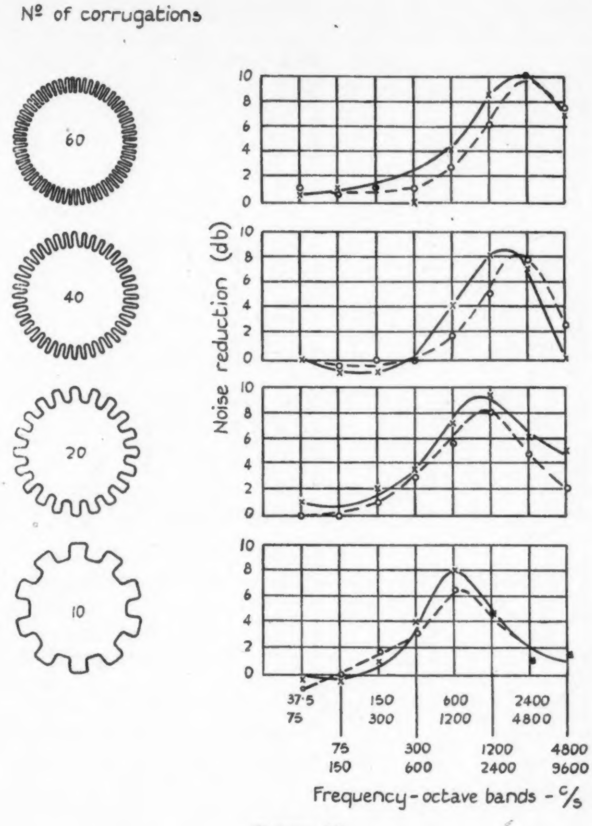


Figure 11
Rolls-Royce tests showing noise reductions with various corrugated nozzles

Needless to say, a vital part in these deliberations has been the thrust loss resultant from the change of nozzle shape. The test rig at Rolls-Royce allows the accurate measurement of thrust under static running conditions. For modest suppressions of the type shown, the thrust loss is small and hardly measurable. This remains a major problem, however, because of the enormously large growth penalty of any weight increase and on the other hand the minimizing effect of the logarthmic decibel scale on any reduction in fluctuating pressure.

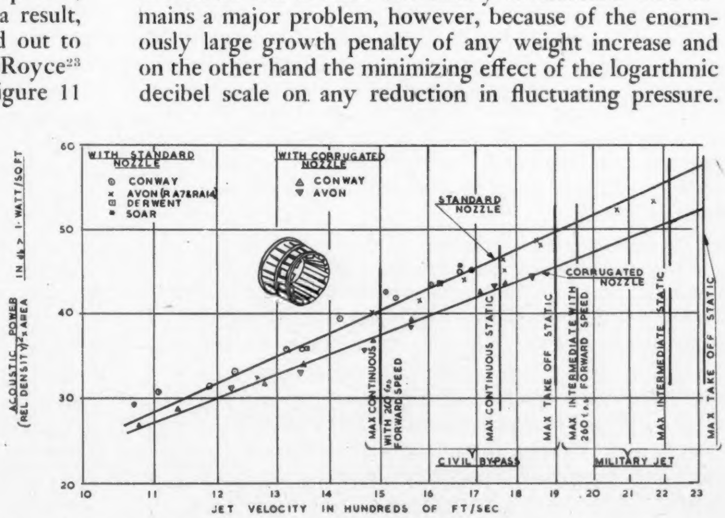


Figure 12
The variation of total acoustic power with jet velocity and nozzle shape

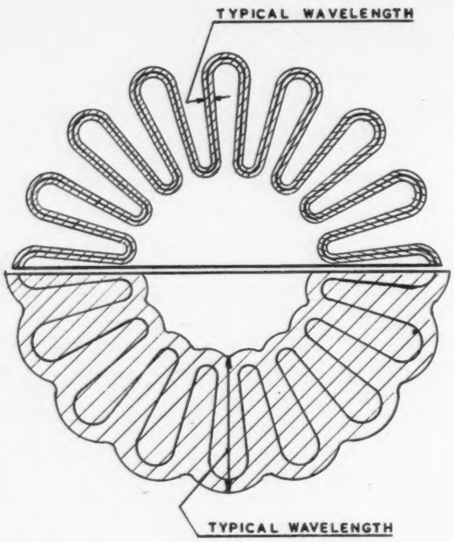


Figure 13
The quick mixing by corrugations eliminates eddies of certain sizes

Three other conditions have to be considered in assessing the merits of these nozzles, the first of these being the changes in pressure fluctuations on the fuselage and tailplane as a result of the quicker mixing rate of the jet and the forward movement of the region of low frequency burbling. It is a point well worth mentioning that a nozzle designed to give a noise reduction for people on the ground may give greater pressure fluctuations on the structure. Aircraft have been fitted with corrugated nozzles in the United Kingdom to examine this and other aspects.

The second and third conditions, respectively, are the practical need to integrate the silencing nozzle with a thrust reversing device and to provide adequate jet cooling by induced flow. All these aspects and any danger of the extended nozzle upsetting the critical Mach number of the aeroplane as a whole are being examined in the United Kingdom. In this connection, retractable devices may in the end prove the more acceptable and are being considered by the engine and airframe firms in the United Kingdom; thus more drastic nozzle modifications can be made to operate at takeoff and landing with only an initial weight penalty and no loss of overall fuel economy.

In addition to the above full-scale work, model experiments are being pursued at Cranfield and at Southampton. It is too early yet to comment on these; one point should, however, be made. The great deficiency in such work is the lack, other than the general idea of mixing quickly, of a physical model of the means by which the noise suppression occurs. For example, the introduction of corrugations increases the peripheral length of the mixing region even though it shortens its length downstream. Some idea of the mechanism can be obtained, however, if only the frequency distribution is examined and not the amplitude. An examination of Figure 11 illustrates this, the frequency for maximum suppression being closely associated with the corrugation spacing. An explanation for this may be obtained by considering the rate of spread of the mixing region along one of these complicated corrugations. The frequency of sound emission will essentially be related to the scale of the turbulence (i.e. the magnitude of the eddies) and typically this will be no greater than the width of the mixing region. Thus, if as shown in Figure 13, the nozzle shape is so designed that the width of the mixing region and, therefore, the eddy size changes relatively abruptly as the corrugation fills, frequencies corresponding to wavelengths in between these two widths will tend to be absent and the noise suppression will be greatest in this frequency region.

It is interesting that practically all noise suppressors can be explained in terms of frequency change in this way. Certainly Withington's results[24] bear this out. And it is a most important experimental observation that the high frequency content, while being a little higher, never reaches the proportions expected. Thus, allowing for the greater atmospheric attenuation at higher frequencies and the relative ease of soundproofing against high frequencies, there does seem some reason generally for frequency raising even though the annoyance to the human ear is greater at high than at low frequencies.

At Southampton we are examining the turbulence from a circular and corrugated jet to establish the validity of the above physical model. We are also photographing superheated steam jets where the mixing region has been made visible by condensation. Much work has been done at Southampton also on more radical nozzle changes into long thin slits[25, 26]. By altering the nozzle to a peripheral unit with a peripheral radius equal to three times the circular radius, a frequency change of between 2 and 3 octaves is obtained and noise reductions of some 15 db (Figure 14) obtained. Suggestions regarding the application of this approach to both helicopters and ground mufflers are shown in Figures 15 and 16 respectively. The length of the slit in the above experiments was extremely modest and intended only to illustrate the principle of frequency conversion. The noise suppression to be obtained, on the other hand, and the performance

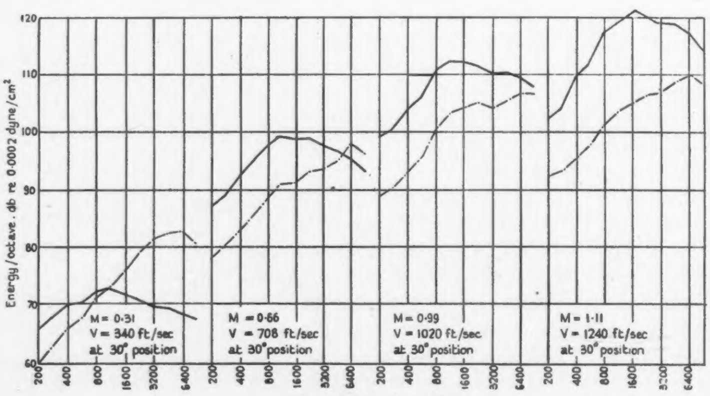


Figure 14
Comparison of spectra from jet and radial spreader at various exit velocities

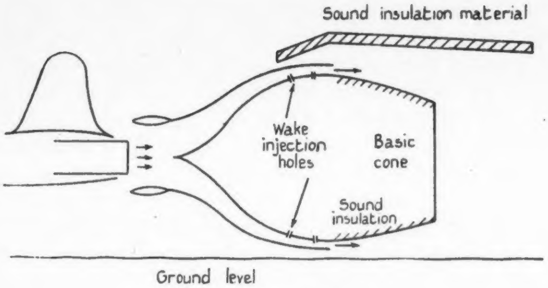


Figure 15
A ground test cell using a peripheral spreader

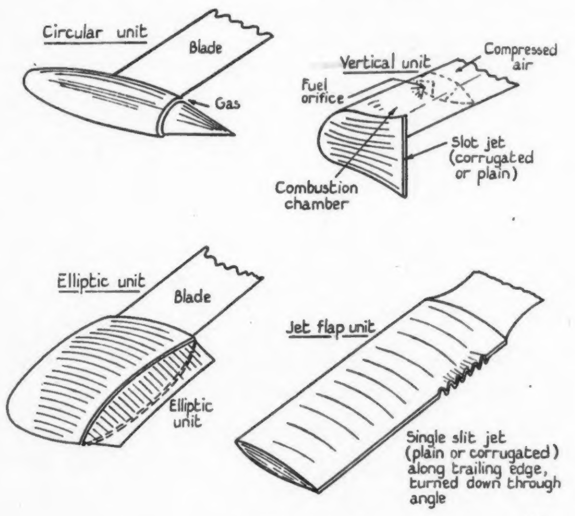


Figure 16
Practical applications of long slit nozzles to helicopter tip jets

gain by extending it until it becomes a jet flap[27] are vast and these are some of the reasons for our interest in the jet flap in the United Kingdom.

Ground Mufflers

It is safe to say that devices (retractable or non-retractable) are feasible which can give reductions of 10 to 15 db in flight and can be incorporated into the next family of airliners without too serious performance losses. Aeroplanes with such noise reductions will be acceptable to the community for short periods in and around airports where the background of aeroplane noise is, in any case, fairly large already.

Unfortunately, there are other conditions of engine running which require more stringent solutions to the noise problem. Ground tests carried out fairly often at the airlines maintenance and test centres to check modifications and inspection changes are likely to be carried out during the night, a time when the normal noise threshold has been reduced by some 20 db or so. Thus, for extended running under night conditions on the ground, some additional silencing devices will be necessary over and above those fitted to the aircraft for normal flight.

Two methods of noise reduction, probably used concurrently, are being considered in the United Kingdom. The first is to so arrange the testing station such that the direction of the nearest houses coincides with the direction of minimum annoyance. Much can be done in any new airport by the suitable location and orientation of test sites and by the intelligent use of maintenance hangars and walls for screening. Unfortunately, most airports have already been developed and the amount of reduction obtained by suitable siting cannot be enough in the majority of cases. The other method, which is becoming prevalent, is the addition of ground mufflers of a portable or more permanent nature during periods of running-up. Much work has gone into the development of such devices during the last ten years with varying success and certainly with varying complication. They vary from completely closed cells, of the type in which normally aircraft engines would be tested in the development stage, to small portable mufflers clamped on to the engine for a particular run. Since it is impossible in this paper to cover all such items, it is proposed to describe three new and promising approaches being used or developed in the United Kingdom at the moment.

In the category of permanent installations, the most successful[28] is the combination of Cullum silencer and test pen installed at Chilbolton. This takes the form of a pen, open at the top, and large enough to enclose the aircraft for which it is intended. The walls are of 9 in brick, 12½ ft high and lined on the inside with 3 in of rock wool behind a perforated metal sheet. The front end is closed by sliding doors, similarly lined on their inside. The jet is discharged through a muffler, whose length is about 40 ft, lined with absorbent material and of a general design shown in Figure 17. The noise radiated in the rearwards direction is reduced effectively by the muffler itself, but this is not sufficient since much of the noise is still radiated forwards. Thus, the function of the pen is to absorb, without any interference to the engine, as much as possible of the remaining noise by its sound absorbent material and by throwing up a shadow to alleviate the level of noise in the immediate vicinity. The noise pressure levels, measured at a distance of 1,000 yds from the aircraft in its pen, 20° from the jet axis, with the engine running at its maximum rpm and with the afterburner in operation, are shown in Figure 18 both with and without the silencer and pen. The background noise measured at the same point is practically the same as that with the muffler and pen in situ; thus, as far as this engine is concerned, the muffler and pen are a complete answer to the ground running problem. The cost of such an installation is not enormous (about £10,000), a far lower figure than similar installations giving less satisfactory reductions tested in the USA. Needless to say, a test unit capable of coping with the future airliners will cost more than this and will involve less convenient installations. For example,

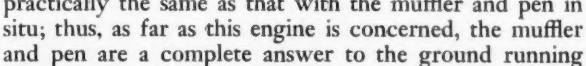


Figure 17
Diagram of Cullum detuner showing spread of the jet

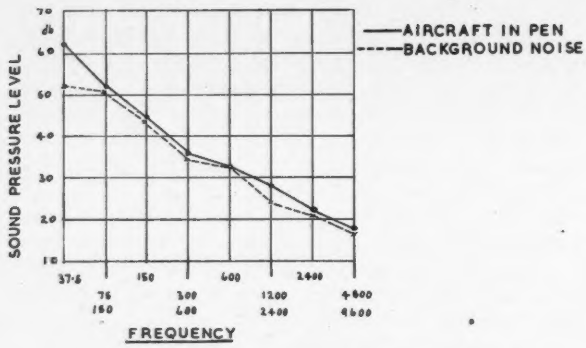


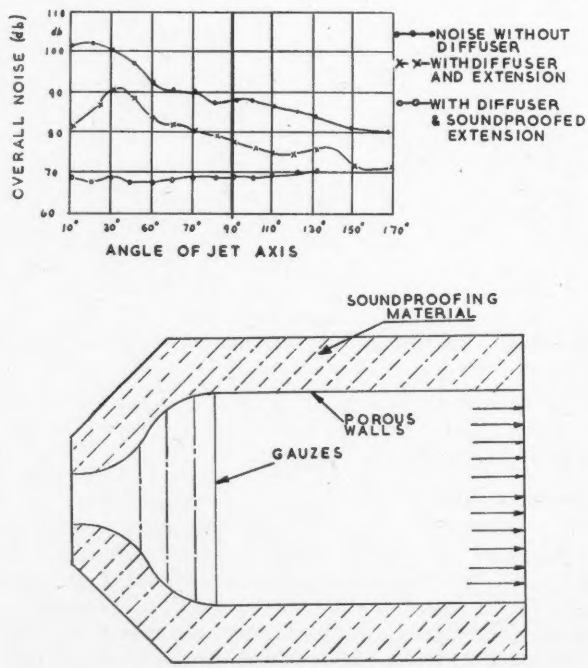
Figure 18
Noise of an aeroplane in Chilbolton sound pen at a distance of 1,000 yds

similar tests on a Javelin twin engine fighter both in and out of a pen[29] indicate poorer attenuations owing to the larger entry flare and the noise propagated forwards from inside the flare. Experiments are to be made to reduce this effect by the use of absorbent screens in close proximity to the entry flare. Still further difficulties have faced the designers of a muffler for the Valiant[30]. Nevertheless, our knowledge of silencing techniques is such now that installations can be devised to give good results.

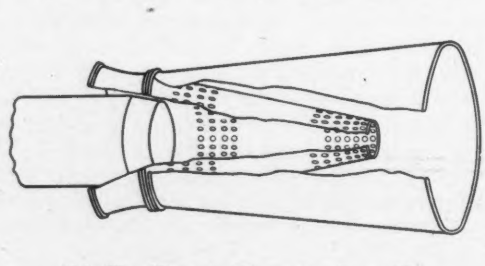
The great objection to all these arrangements, needless to say, is their cumbersome and expensive nature, particularly for use under conditions where every half hour is vital to the earning capacity of the aeroplane. For this reason, work has been carried on at Southampton[25] and Bristol[31] on lightweight ground mufflers, which aim to change the nature of the sound at source rather than to suppress it after it has been formed. Indeed, the satisfactory results obtained from the Cullum silencer cannot easily be explained by sound-absorption qualities only and may well result from a jet-changing mechanism. It is seen from Figure 17 that the dimensions of the units are so chosen that the tunnel flows fully over practically its whole length. Therefore, it may well be that one of the contributing factors to the silencing in this instance is the mechanics by which the high-speed jet is modified in the silencer to a much lower velocity jet of larger diameter.

This principle of diffusion through an attached trumpet has been taken a step further at the College of Aeronautics[32], who have put forward an extension unit of the type shown in Figure 19(a). The normal breakaway that would occur owing to the large diffuser angle is eliminated by the addition of a large number of gauzes or their equivalent, which set up a pressure gradient equal and opposite to that caused by the increasing area; thus large noise reductions have been obtained on a model with no entry gap; tests with a satisfactory open entry system are being planned.

The other principle, which has been described earlier in the paper, is that of altering frequency[25] by changing the shape of the air efflux either out of a long slit or out of a series of small holes. The former device, which indicated some 15 db reduction with the spreader on its own and larger reductions with an added sound-proofed extension, is being tested at full-scale on a jet engine at Rolls-Royce and is showing similar reductions. Needless to say (when weight does not matter) these basic methods of noise reduction can be combined with great effect on units where back pressure does not matter. The advantage, however, of the frequency changing system is that no net force need act on the silencer unit. It can, therefore, be wheeled from place to place and attached to the aeroplane with the minimum of fastening. This advantage may well outweigh other considerations in setting up a satisfactory unit for test. Practical adaptions which use a combination of both the frequency-changing and the diffusing mechanism are being tried in England, one such unit under consideration being that shown in Figure 19(b). Tests carried out on such a unit at the Bristol Aeroplane Company[31] indicate modest reductions of about 10 or 12 db in the lower frequencies. Further investigations are to include optimization of hole size, arrangements for nozzle trimming, the effect of increasing the divergent angle of the outer cones and lagging it to reduce the high frequency content.



(a) The Cranfield wide angle diffuser showing noise measurements with and without soundproofing



(b) The Bristol "Pepperpot" muffler

Figure 19

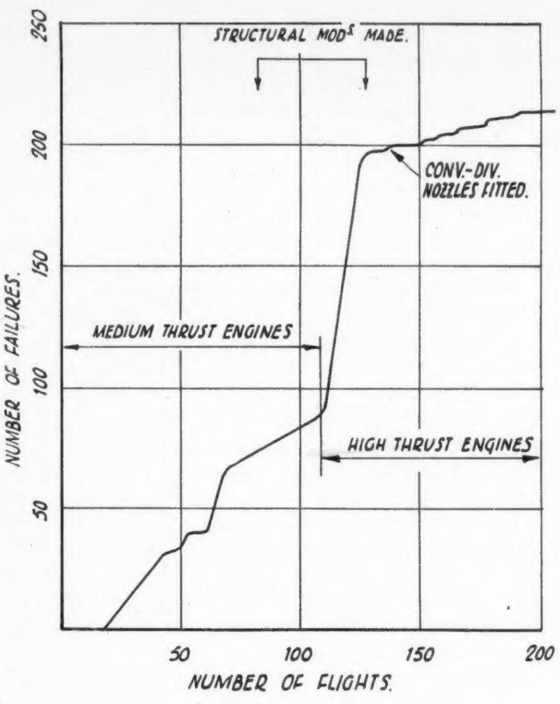


Figure 20
Damage rate for a typical aircraft

THE EFFECT OF NOISE ON AEROPLANE STRUCTURES

It is somewhat surprising that in the United Kingdom the greatest objector to jet noise has been not the public but the structure of the aeroplane itself. As in the USA[33], practically all firms involved in flying very fast jet aircraft have some degree of difficulty aft of the jets with rivets failing, cleats fracturing and skin cracking. As an example of the early history of a typical aeroplane, Figure 20 shows the numbers of minor failures of cleats, rivets and stringers plotted against the number of takeoff runs. Fatigue failures occur very early in the life of any airframe owing to the high frequency of the excitation and the short time needed to build up the number of reversals usually associated with fatigue. The types of failure experienced are shown in Figures 21 and 22 obtained under test conditions in a programme of work carried out by Vickers Armstrongs Ltd.[7] Figure 20 indicates clearly the sensitivity of the structure to increased thrust, to structural modifications and to the jet mixing rate. Unfortunately in this particular instance the structural changes and nozzle redesign were introduced together so that the contributions to the cure of each cannot be established.

What are the additional problems involved in dealing with the reaction of structures rather than people? They are in fact very great indeed and are worth setting out carefully. They are:

(1) The human ear is conscious of the pressure fluctuations at a point, i.e. the amplitude. The structure is conscious of the amplitude and the area over which the pressure is "correlated", i.e. the area in which the pressure adds up to excite any particular mode of vibration. Thus the structural aspect involves phase as well as amplitude investigations.

(2) From the public reaction point of view, it is generally acceptable to think only in terms of people some way away where the pressure fluctuations will be only those radiated acoustically. The structure will generally be in the "near field" where pressure fluctuations occur both because of the structure being in the turbulent flow and also because of its being in the "reactive" non-radiated field of the source.

(3) The ear drum can to some extent be considered a "standard article", i.e. the same from person to person. Average rules regarding response can, therefore, be built up. The response of an aeroplane structure depends on the excitation and has an infinite number of modes of oscillation. Methods of calculating these modes with known excitation fields are still of a primitive nature on structures consisting of skin, stringers and frames. The degree of structural damping is crucial and alters considerably from riveted to sandwich construction.

(4) Since the ear drum is a "standard article", a subjective assessment of its behaviour can be made, e.g., 140 db will give pain, 160 db will cause it to fatigue and break. The structure of an aeroplane is anything but standard. Thus, even when the statistical figures for the stress levels arising from the near random loadings are calculable, the accumulated damage laws have to be more clearly established to assess its fatigue life.

Since the gaps in our knowledge extend to each and all of the above items, there can be no likelihood of an early analytical solution to the whole problem. The work going on in the United Kingdom consequently separates out into, on the one hand, a series of ad hoc examinations of typical structures placed in the region of intense noise excitations from actual representative jet engines; on the other hand, a series of loosely connected fundamental analyses and experiments at my University covering almost all the items listed above. Since this latter programme is essentially a long term one, let me describe first the more immediately useful work at Vickers Armstrongs (Supermarine)[7], Royal Aircraft Establishment, Farnborough[6, 34], Rolls-Royce and De Havillands[35].

A general description of the work going on at Vickers Armstrongs Ltd. is given by Hetzel[7] in the recent symposium of the Royal Aeronautical Society. Generally

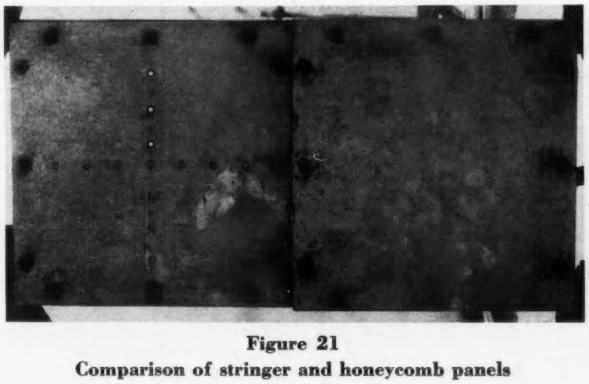
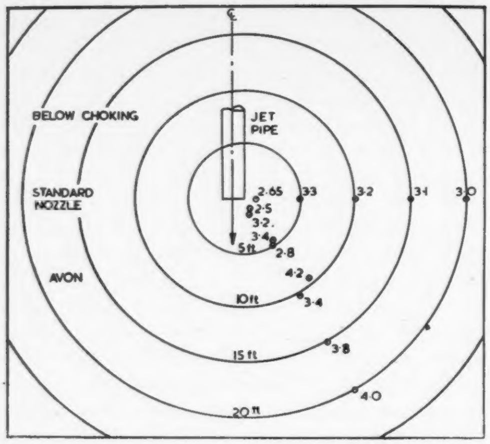
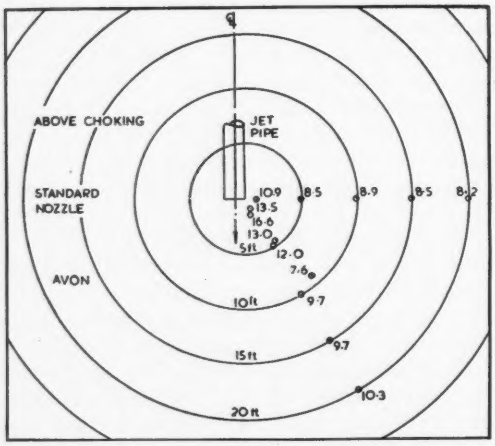


Figure 21
Comparison of stringer and honeycomb panels



(a) Near field values of *N* in the expression noise $\propto V_J^N$



(b) Near field values of *N* in the expression noise $\propto V_J^N$

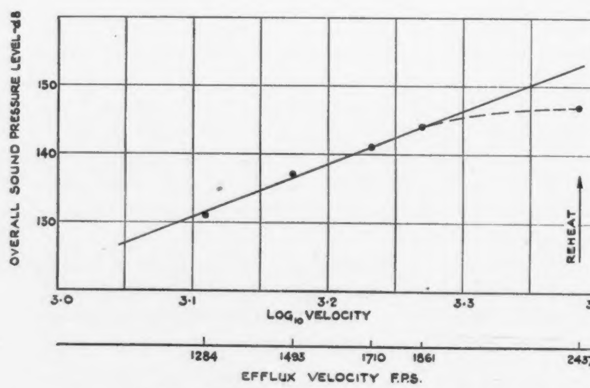
Figure 22

the work has consisted of an assessment of the near field pressure fluctuations on a typical jet engine and on the response of the rear fuselage of a typical fighter. Two items in the work are worth mentioning, apart from the invaluable subjective experience obtained by the firm on their type of construction (i.e. the establishment of the strength of their particular "human-ear"). During part of their endurance testing, two small panels were mounted below the fuselage so as to be subjected equally to the pressure fluctuations. The panels were of the same weight per unit area but one was of sandwich construction, the other was braced with a cross of conventional Z stringers. As shown in Figure 21, rivet failure occurred on the stringer panel after a few hours running while the sandwich panel remained intact. This emphasizes the need to provide rigidity in structures close to a jet efflux. It also emphasizes the value to be obtained from installing samples of typical structures around jet engines under test in cells and in the open. In the United Kingdom this policy is being followed, though it has been often found that the existence of suppressor units in the test cells have rendered the noise close to the jet to be quite unrepresentative.

The second point concerns the complete change in the near field and far field pressure fluctuations when the jet becomes choked. Figures 22(a) and (b) show this variation, the figure plotted being the index of the sound intensity variation with jet efflux velocity. It is clear that much work is needed to provide further data in the practical takeoff condition where it is not by any means clear whether or not the jet is choked. In this connection Franklin[8] has analyzed the subsonic noise data to provide rules for designers to assess the excitation levels in the near field. More recently Wolfe[34] at RAE has carried out a thorough near field survey in the various one-third octave frequency bands. The influence of reheat is shown in Figure 23. It is to be seen that at velocities above 2,000 to 3,000 fps, the noise does not continue according to the usual velocity law, the sound pressure level being 5 db down in this particular case. Here it may well be that the increased temperature has resulted in a reduced Mach number in the jet. Nevertheless, rocket noise figures consistently show levels which are 10 db below the normal velocity law. Because of this and because rocket noise is likely to be significant in the future, we are at present engaged in a joint rocket measuring programme with RAE (Westcott) to study the deviation of the empirical noise laws at very high efflux velocities.

Other ad hoc work in the United Kingdom has concerned itself with structural problems on particular aircraft, for example, by De Havillands Ltd.[35] and RAE[34] on the Comet and by Vickers Armstrongs Ltd. on the Valiant. No broad conclusions have been reached, though they have confirmed previous thoughts that, since there are no discrete frequencies in jet noise, there is not much hope of detuning the structure and that, since most of the vibration is confined to panels, it is sensible to stiffen the structure as much as possible in the regions of maximum excitation. This suggestion that vibration is confined to panels is challenged by Powell[36] who shows in a general and extremely useful analysis of the problem that conditions are right for complete fuselage panting to occur.

As stated previously, a general programme of fundamental research on most of the basic topics mentioned above is going on at Southampton and a general method



AT 20FT. RADIUS AND AT 60° ANGLE FROM AXIS OF JET
VALUE OF INDEX "n" (DETERMINED FROM SLOPE) = 3·84

Figure 23
The effect of reheat

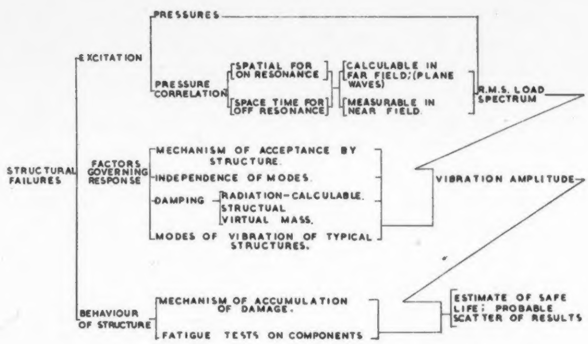


Figure 24

The researches needed to overcome the problem of the effect of noise on structural fatigue

of assessing structural damage once the various factors are known has been put forward[36, 37]. The programme thus covers various parts in the linkage of research problems shown in Figure 24.

Since no progress can be made until the space and auto-correlations[38] near jets of various shapes operating at various pressure ratios are established, McLachlan has developed the general purpose correlator shown in Figure 25, while Franklin has developed the probe microphone system shown in Figure 26. This equipment is the basis of a new programme of auto-correlation and spatial correlation which should provide extremely valuable information both regarding structural response work and noise source positions. The correlator is a general purpose unit covering completely the 0-10,000 cps range and is intended also for use in other researches on wing buffeting, aircraft recognition, loudspeaker design and in medical researches where very low frequencies may be important. The auto-correlation work is involving the design of high speed magnetic tape and drum systems suitable to give delays between −20 msec and +20 msec. The microphone probe has a length of 9 in and an internal diameter of 0.031 in. With its amplifier, it is satisfactory for use in the frequency range 100-10,000 cps when used in conjunction with a Bruel and Kjaer microphone. Detailed descriptions of both the above are in process of being written up.

On the more structural side, a new method of calculating the modes of oscillation of a stiffened fuselage has been put forward by Miller, while a series of progressively complicated analyses of the behaviour of structures excited in a random way are being carried out by Foxwell. These include the response of a stiffened cylinder excited by a plane sound wave and an extension to random noise excitation. This work should establish the effect of the acoustic field on the cylinder response. The excitation of a stiffened cylinder by boundary layer noise is also in mind.

A further link in the chain involves a fundamental analysis of structural damping by Mead[39], the programme including the feasibility of damping inserts, rivet behaviour and new damping compounds. It is considered that suitable additions of structural damping may reduce the stress level in a structure by 70% or even more. A stiffened cylinder is being constructed for experimental work to confirm much of this work. A rather different approach is given by Young[40] to obtain the transmission of random noise through a stretched membrane.

In parallel with these various researches, I would like to mention the week's course on Aeronautical Acoustics which we offer each year to members of industry, operating companies and research establishments. By this means we have introduced the many new fields of knowledge, such as aerodynamic noise, random processes, structural

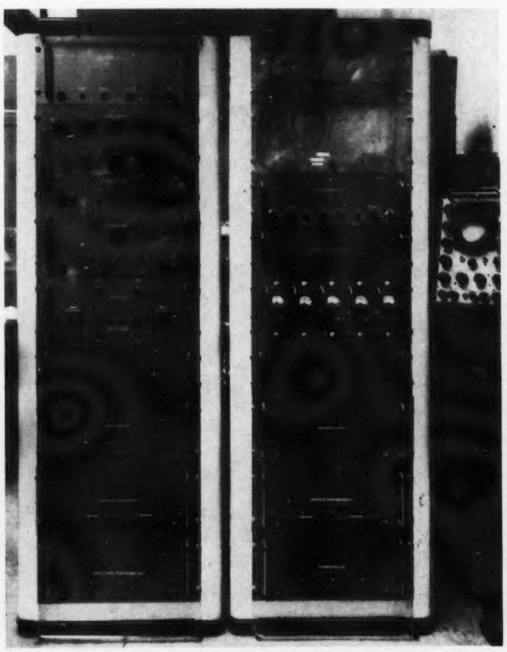


Figure 25

University of Southampton Correlator for noise work — covering the frequency range 0-10,000 cps

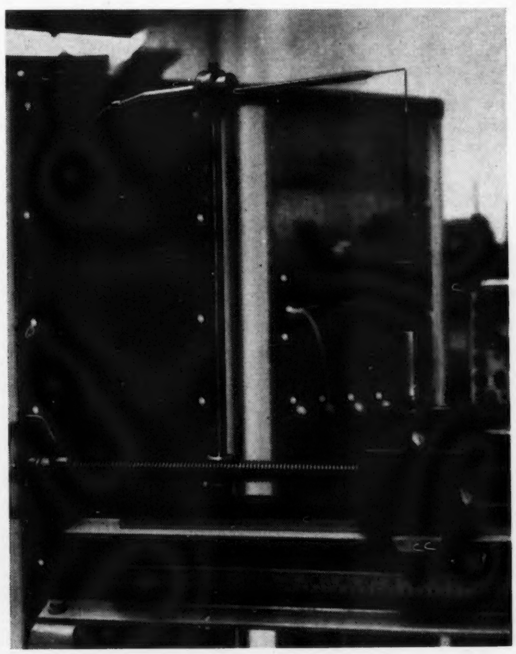


Figure 26

Condensor type probe microphones used for spatial correlations at University of Southampton

vibrations, acoustics, noise psychology and physiology, to the ever increasing numbers of people who are becoming involved in what is rapidly becoming a major design factor in aircraft design. I hope that you in Canada will send your representatives in due course.

BOUNDARY LAYER NOISE

The production of noise from turbulence is related essentially to the relative velocities of the two adjoining streams; thus, as far as jet engines are concerned, except in so far as their pressure ratio increases with altitude, the worst condition by far is that of static running on the ground. Indeed, it has been a matter of experience that structural vibrations due to jets are very much less in the air. There are, however, regions of very high velocity shear on supersonic aeroplanes, for example, in boundary layers and in the wakes of air brakes, where the shear is aggravated with increasing forward speeds, causing noise and vibration to occur throughout the whole flying time of the aeroplane. If the unfortunate combination of a high velocity shear and a fairly thick boundary layer occurs, such as behind an air brake, the resulting high intensity low frequency excitation is known to have caused much damage.

In the United Kingdom, the only flight measurements of boundary layer noise have been made on a Canberra[41], it being found that in the cockpit engine noise was inaudible above a Mach number of 0.4.

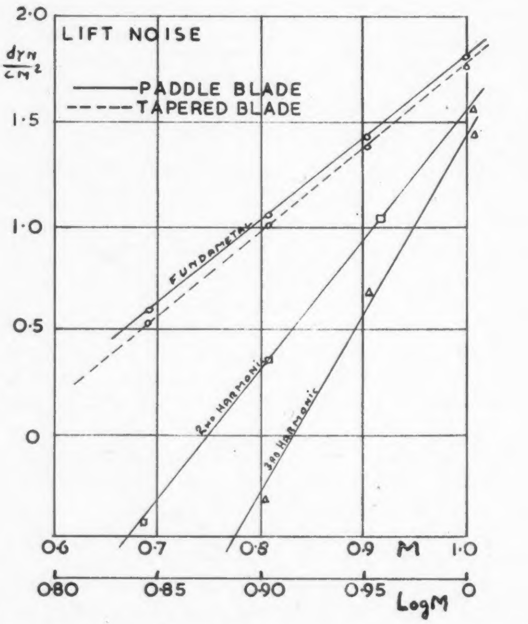
Several theoretical approaches have been made by Curle[42], Phillips[43] and Powell[44] which are by now well known. The controversy of whether or not dipole noise can occur in the boundary layer has been resolved and a good theoretical framework produced to deal with the noise propagated from a boundary layer of a flow along a solid boundary. The very interesting problem of the propagation of this noise through flexible structures has not been tackled except as mentioned earlier.

At Manchester University, experimental work to examine the sound propagated from rigid wall boundary layers is being carried out by Doak, who has built a special wind tunnel with a working section 5 in square and about 10 ft long; this is attached by way of a sonic throat to a vacuum system, thus isolating the working section from downstream noise. Speeds approaching the speed of sound have been attained in it for durations of roughly a minute. Unfortunately, while the throat has prevented the upstream propagation, considerable difficulty has been had in eliminating transmission through the wooden structure. This has now been overcome and tests are proceeding.

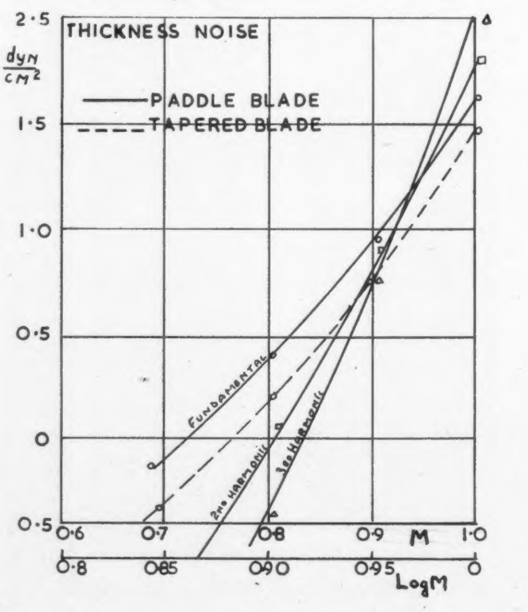
The College of Aeronautics is now re-entering the field of jet noise with experiments to investigate the noise from a jet in the presence of plane boundaries. Initially the surfaces will be rigid but the rig will be designed so that flexible plates can also be fitted. Surface measurements of fluctuating pressures in addition to noise measurements in the radiation fields will be made. It is proposed also to develop probe-type microphones for auto and two-point pressure correlation of measurements across the jet. (For certain measurements a radially symmetric jet model is proposed which will have the advantage of eliminating the end effects that will exist on the pseudo two-dimensional jet.) The jet will also be tested at various distances from the rigid boundary.

With this jet model (which is representative of a blown flap under ground running conditions), the relative importance of the quadrupole noise source fields in the boundary layer and the jet and dipole noise source field in the boundary layer will be investigated at subsonic and supersonic speeds.

Later comparative tests will be conducted in which the rigid boundary is replaced by suitable flexible structure. Noise transmission measurements will be made.



(a) Growth of propeller higher harmonics with increase of Mach number



(b) Curves showing the increase in thickness noise with Mach number and the growth of the harmonics

Figure 27

PROPELLER NOISE

Until two years ago, propeller noise research was notable by its absence in the United Kingdom, the emphasis, as a result of the operation of the Comet jet airliner, being on jets rather than on propellers. At that time propeller research was emphasized in the USA. Now the situation has, to some degree, reversed itself, owing to our confidence in the Britannia and Vanguard aircraft; and the problem of propeller noise is taking its modest place along with jet and boundary layer noise in our activities. To quite an extent, this interest is based on an ever-increasing awareness of the intractability of the jet noise problem and the belief that high powered and high speed aircraft will be used only where their economy is substantially better than that of their slower speed counterparts. There is no interest in supersonic propellers but rather an interest in understanding the noise and its transmission into the cabin of propellers whose helical tip speeds are in the region of and slightly exceeding the speed of sound. Theoretical studies by Diprose have shown[45] that the increase of tip Mach number from 0.85 to 1.0 results in considerable increases in "thickness" noise rather than "lift" noise. As shown in Figures 27(a) and (b), the harmonics grow in amplitude to such a degree that they overshadow the fundamental frequency and present the need to study the fuselage response to an entirely different range of frequencies. This complete change in the excitation calls for a thorough analysis of the structural response, since empirical noise charts are based chiefly on noise transmission at the fundamental 4P frequency and there is every likelihood of large errors occurring in the assessment of the relative importance of tip speed and tip clearance in this new regime. Such work is planned in the United Kingdom. Swift at Southampton is calculating correlation areas for the various harmonics with this in view and proposes to examine the response of simplified structures afterwards.

An essentially practical programme of propeller noise research is being carried out by the Bristol Aeroplane Co. to investigate the nature of propeller noise propagation into the aircraft and the effect it has upon the structure[46]. The programme is in two distinct sections, firstly, a complete series of investigations is being conducted with a 20 ft long section of a Britannia fuselage which can be excited acoustically by means of two high-powered loudspeakers of special design to simulate the inboard propellers. The second part of the programme is concerned with flight investigations into propeller noise generation and its dependence upon forward speed, blade loading, rotational speed, altitude and phase relationship.

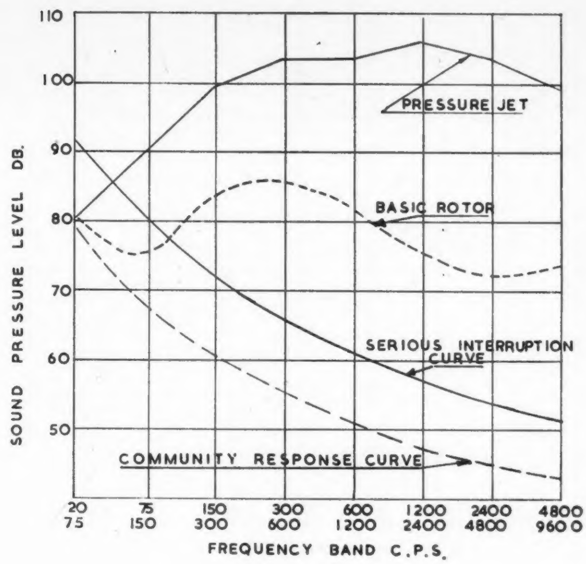


Figure 29
The noise of tip jets and basic rotor systems together with annoyance and interruption curves

Theoretical work and experiments are being carried out in the propeller firms on phase synchronization, a procedure likely to become standard in future propellered aircraft.

The above programme is not vast and results are likely to be modest. They do, nevertheless, allow a body of knowledge to be obtained in a field in which otherwise serious problems might arise in the future without there being any background knowledge to tackle them.

HELICOPTER NOISE

The same remarks may be applied to helicopter noise research in the United Kingdom. One very active industrial group, Fairey Aviation Ltd., are actively pursuing a programme of tests to reduce the noise of pressure tip jets[47] to acceptable proportions. Some idea of the extensive nature of the programme is obtained from Figure 28 which shows a collection of some of the nozzles so far tested. In my analysis of the helicopter noise problem[48], I concluded that the noise reductions necessary to make pressure jets acceptable could be determined not on the basis of annoyance curves but rather on the basic levels arising from the rotors themselves (Figure 29). Thus overall noise reductions of 20 db are required in the high frequency end of the scale. Some of the devices tested show alternatives of as much as 13 db overall noise in the positions of maximum intensities. That the reductions arise from a frequency conversion is indicated from Figure 30, in which the attenuations over a series of cross-tail nozzles are plotted against the slot width. The Fairey report shows that a considerable thrust loss occurs with these nozzle shapes and that the noise index is very far from the eighth power law.

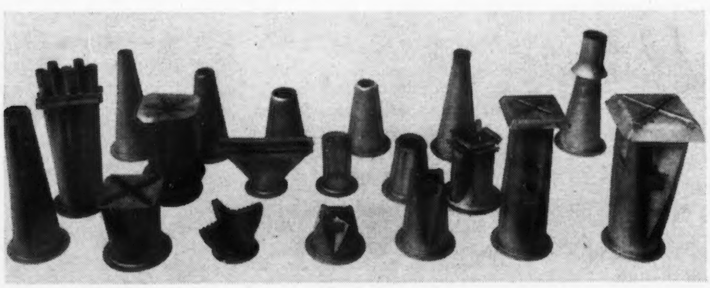


Figure 28
Some tip jet nozzles tested by the Fairey Aviation Co.

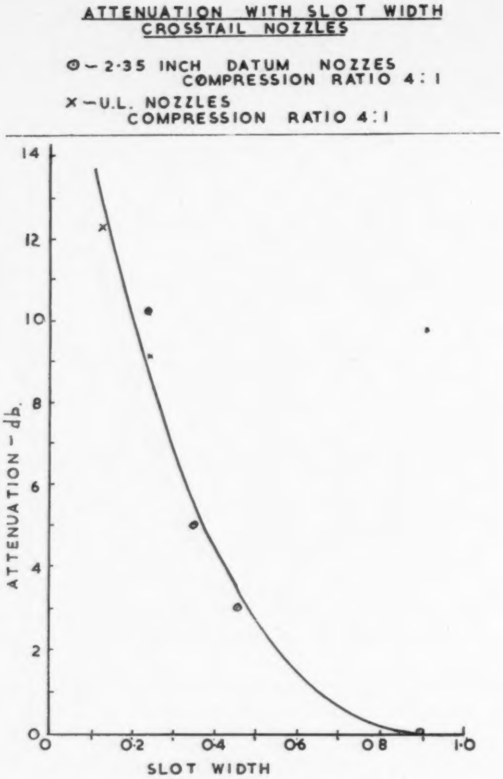


Figure 30
The variation of noise attenuation with slot width

This suggests that other significant parameters enter into the experiments, such as the initial turbulence or the slots not flowing full at all jet velocities. It is too early, therefore, to deduce anything from the Fairey tests except that they do fit the general model for noise suppression by frequency conversion mentioned above. With this in mind, the schemes of Figure 16 are again emphasized as possible ways around the helicopter tip jet noise problem.

The low speed tip jet work of Hunting Percivals and the pulse jet work of Saunders-Roe have been discontinued in the United Kingdom for reasons of economy. Further noise results have, therefore, not been forthcoming.

CONCLUSION

There are in the United Kingdom other noise researches not specifically related to aeronautical applications. In the time at my disposal, I have not been able to refer to them without losing still further any sense of continuity in the programme. Indeed, I must apologize that, in spite of myself, this lecture has tended to fall into the category of a catalogue. It has, nevertheless, been my aim to give some degree of coherence to the United Kingdom noise programme. What is certain is that the programme is insufficient; what is more certain is that it is as much as the country can afford. The greatest outcome of all has been the gradual emerging of a body of people competent in this new and all embracing field of science who can tackle the problems as they become really serious, a state of affairs which can only be a year or two away from us.

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A COURSE ON THE DART ENGINE

6th to 10th January 1958

A five-day lecture course on the Dart has been arranged for members of the C.A.I. by

ROLLS-ROYCE OF CANADA LIMITED

In response to a Notice appearing in the September issue of the Journal, a number of members have already enrolled, but there are still vacancies and any other members who may be interested should apply to

Mr. K. H. Parker, Rolls-Royce of Canada Ltd. Box 1400, Station O, Montreal 9, P.Q.	or	The Secretary, Canadian Aeronautical Institute, 77 Metcalfe Street, Ottawa 4, Ont.

There will be no charge for the course but members attending must bear their own expenses.

TECHNICAL FORUM

Education and Training

THE excellent session on "The Shortage of Technical Personnel", as conducted by Professor Loudon at the recent CAI/IAS Joint Meeting, resulted in a spirited discussion of many phases of the topic. It seemed, however, that most of the speakers were thinking of shortages and remedies in terms of a static peacetime national situation. Consequently, the session left one with the impression that any shortages of technical personnel were merely a matter for readjustment rather than for any real concern. In view of the increasingly unfavourable military and technological situation of the Western nations, including Canada, this impression surely deserves further comment.

The connection between national security and technical manpower resources is obvious and needs no elaboration here. It would seem vital, therefore, that any serious deficiency of technical capability should be made a matter for national concern, so that corrective measures can be undertaken without delay. Judging by the recent trend noted above, such a deficiency does now exist.

Fortunately, experience has shown that matters affecting the security of the nation generally receive prompt attention after public and official attention has been focused on them. Some way of bringing this situation to the attention of the public and of the responsible government authorities is, therefore, required.

The C.A.I., as a large, well established and responsible organization, is now capable of exerting considerable influence in public affairs. The time may have arrived, therefore, when the C.A.I. should consider whether it has a responsibility to warn the nation of the present situation and to advise on corrective action needed.

Speaking as an Institute member, may I respectfully suggest that the C.A.I. has such a responsibility and that appropriate action should be undertaken at the earliest possible time.

Ottawa, Ont. W/C E. E. McCullough

I LISTENED with interest to the informal discussion on "The Shortage of Technical Personnel" at the CAI/IAS Joint Meeting in Montreal on October 22nd. The case, I think, was well presented and the suggestions put forth to alleviate the shortage of technical manpower in Canada are certainly worthy of further consideration.

My opinion in this matter of national importance is that more emphasis should be placed on the raw material than on the almost finished product. To further educate those already in the technical field is all well and good but this does not serve to attract more numbers. Should it not also be the aim to create an environment that would induce the youth of Canada to strive for higher education.

It is my opinion that the inability of our youth to apply themselves is due primarily to the leisurely system of education in our primary, public and high schools and to the social and economic conditions under which we live. Perhaps by talking to our children and observing them closely we can find the answer. Not too long ago, I was urging my young son to do his homework in a diligent manner. In trying to make my point, I stated that if he worked hard and developed a liking for study, he would become a professional man, perhaps an engineer like his father, and then he could buy the luxuries he wanted. He looked at me and said that the caretaker of the apartment blocks in which we lived had a nice shiny big car while we had a well-used tiny European make. Perhaps the boy hit the nail on the head. Why educate yourself when you can make easy money without doing so.

I submit that our educational system be revised so that our children commence school at an earlier age and so that they are nurtured in their most receptive years in a technical atmosphere and in environmental conditions which stress discipline, the satisfaction of a job well done, the meaning of fair play and how to lose in a sportsmanlike manner. In effect, I advocate adoption of some of the features of the educational and social systems of England and Germany in preference to the coddling, leisurely, T.V. and comic book type of North American educational processes and in the all too prevalent almost complete equality in the social system existing in our continent today. In brief, I feel that there must be a revision in the Canadian educational and training system and that there must be a readjustment in values so that it pays to be better educated, if we are to overcome the shortage of technical personnel at all levels.

I believe that the matter of inadequacy of Canadian technical manpower is of national concern and, as a member of the C.A.I., I suggest that the C.A.I. has a responsibility in bringing it to the attention of the Dominion and Provincial Governments.

Ottawa, Ont. S/L W. P. Maguire

(Our correspondents are referred to the section on Education and Training contained in the Annual Report of the Council, 1956-57, which was published in the September issue of the Journal; the section in question appears on page 246. The Institute's work in this field is still continuing. A meeting of the Chairmen of the Provincial Committees took place in Montreal on the 20th October and it was most encouraging to learn of the progress which these Committees are making.

Further correspondence on this subject is invited; for discussion and the interchange of ideas are certain to be valuable in guiding the Council and the Provincial Committees in their endeavours. — Sec.)

C.A.I. LOG

SECRETARY'S LETTER

ASSISTANT SECRETARY

MEMBERS will be interested to know that W/C H. L. Taylor joined the staff as Assistant Secretary at the beginning of December. His appointment comes as a very welcome relief to me and I am sure that once he has the feel of the Institute we shall, between us, be able to extend the services which every member has a right to expect from Headquarters.

THE PRESENTATION OF PAPERS

In the November issue of the Journal, we ran a notice about the Annual General Meeting and invited members to consider presenting papers at it. We are running a similar notice this time and I would draw your attention to it, because the deadline is drawing near.

Certain broad subjects have been chosen by the Programmes Committee and a session of the Meeting will be devoted to each. If any member would like to give a paper on one of these subjects, he should submit a brief summary or outline of what his paper would be about, to enable the Committee to judge whether it would be suitable. If it is considered suitable, he will be given the go-ahead to prepare the paper; which will be included in the programme.

I know that the deadline for these summaries, the 31st December, is some way in advance of the date of the Meeting in May, but the Programmes Committee must know what papers it can expect from members, before it sets about completing the programme by invitation.

One of the purposes of the Institute is to develop speakers in Canada. We are not doing badly; since the Institute was formed, a great many Canadians, who would never have thought about it before, have realized that their work was full of general interest and have presented excellent papers at our Institute and Branch meetings. Many of these papers have been subsequently published in the Journal and have been read widely throughout the world. It is all good for Canada's reputation abroad and for the exchange of information among ourselves.

And so I would urge members to think about their work, with a view to picking something out of it which might be worth talking about. Usually a paper is presented with the purpose of passing on to others information which the speaker has gathered in the course of his work. But it is also possible for a speaker to prepare a paper, developing a problem which confronts him and leaving his audience with nothing but a stimulating array of questions to think about. (Mr. Shenstone's "Supersonic Passenger-carrying Aircraft", published in our issue of last January, was a classic example of this type of paper.) Either way the preparation of a paper invariably proves to be useful to the author; if it does not provoke any helpful comments from his audience, it at least compels him to put his own thinking in order, often with most illuminating results.

PROPULSION SECTION

On the 20th November, I visited Toronto to discuss the development of a Propulsion Section. A note about this appears under the heading SECTIONS on Page 374. Although the Council has not yet approved the formation of this Specialist Section, I know that they have encouraged it and I can see no objection to an advance build-up of its membership at this time. Any C.A.I. member who is interested should obtain an application form from his Branch Secretary or from this Headquarters.

50TH ANNIVERSARY

As a supplement to our own planning, the Institute is represented on a body recently set up to coordinate the plans for the 1959 celebrations of all the major aeronautical organizations in Canada. This body is known as the National Coordinating Council for the Golden Anniversary of Flight in Canada and includes the three Services and, at present, ten associations such as ourselves. It has no executive powers but its principal object is to avoid clashes in the programmes of its members and so evolve a nationwide programme worthy of the occasion.

HAPPY CHRISTMAS

I have been asked by the staff to take this opportunity to send to all our members and friends our very best wishes for Christmas and the New Year.

JOINT I.A.S./C.A.I. MEETING

THE fourth in the series of annual Joint Meetings held by the I.A.S. and C.A.I. took place in the Sheraton-Mount Royal Hotel, Montreal, on the 21st and 22nd October, 1957. The programme included six technical sessions, arranged in pairs, and, as in previous years, the W. Rupert Turnbull Lecture. Total registration amounted to 477. The Dinner, held in the evening of the first day, was attended by 603 members and guests.

Mr. E. H. Higgins, Chairman of the Montreal Branch of the C.A.I., and Mr. W. A. Shrader, Director of Publications of the I.A.S., opened both sessions on the first morning with a few words of welcome to those attending the meeting. At the end of the last two sessions, on the afternoon of the second day, the proceedings were closed by Mr. S. L. Britton, Vice-President of the C.A.I., in the one room and by Mr. H. C. Luttman, Secretary of the C.A.I., in the other.

Mr. G. R. McGregor, the Principal Speaker. Seated (l to r) Dr. G. N. Patterson (Turnbull Lecturer), G/C H. R. Foottit (President, C.A.I.), Dr. J. J. Green (Chairman, Turnbull Lecture) and Mr. S. Paul Johnston (Director, I.A.S.)

THE DINNER

At the Dinner, held on the 21st October, the majority of the Head Table guests were the Presidents, General Managers and other senior representatives of the C.A.I. Sustaining Member Companies located in the Montreal area. In his introductory remarks, G/C H. R. Foottit, President of the C.A.I., referred to this Head Table arrangement as an application of the "area rule". He went on to welcome the I.A.S. visitors and called on Mr. S. Paul Johnston, Director of the I.A.S., to say a few words.

A general view of the Head Table at the Dinner

Mr. Johnston, in his reply, referred to the Anglo-American Conference to be held in the Eastern United States in 1959 and said that this Conference might include a visit to the Cleveland district and perhaps a detour into Canada in collaboration with the C.A.I. He also mentioned the proposed International Congress to be held in Madrid in September 1958 under the auspices of the newly created International Council of the Aeronautical Sciences, on which Canada is represented by Dr. J. J. Green, the first President of the C.A.I. and now Defence Research Member of the Canadian Joint Staff in Washington. In conclusion, Mr. Johnston confirmed that the I.A.S. looked forward to many years of close cooperation with the C.A.I. in these Joint Meetings and in other fields.

Mr. E. H. Higgins (Chairman, Montreal Branch) and Mr. W. A. Shrader (Director of Publications, I.A.S.) welcoming the delegates

Registration—Mr. R. R. Dexter (Secretary, I.A.S.) can be seen in the foreground

The Principal Speaker, Mr. Gordon R. McGregor, President of Trans-Canada Air Lines, spoke on the Economics of Civil Turbine Operation. Despite its rather daunting title, for such an occasion, Mr. McGregor's address was a brief and simple exposition of the thinking behind the choice of the fleet which T.C.A. expects to operate during the next ten years and it was admirably suited to his audience. Models of the Viscount, the Vanguard and the DC-8, to substantially the same scale, stood on the table before him as he spoke. His address is published in full in this issue. Mr. McGregor was thanked by Dr. Green, after which the Dinner was adjourned.

TECHNICAL SESSIONS

The programme of technical sessions, held during the two-day Meeting, is reviewed as follows:

Morning Sessions, October 21st

(Two Sessions running concurrently)

NAVIGATION AND AIR TRAFFIC CONTROL

Reported by F. P. Raven

Approximately 80 people attended the session on Navigation and Air Traffic Control, chaired by Mr. C. Bogart of the Department of Transport. After a few opening remarks by Mr. E. H. Higgins, Chairman of the Montreal Branch, welcoming the delegates to the meeting, the first speaker was W/C K. R. Greenaway on the subject of "Global Navigation in High-Speed Aircraft". This interesting subject was ably handled by an experienced lecturer.

Stress was laid on the changes in operating techniques that civil and military operators would implement with the coming jet age. Self-contained aids, such as "Doppler", were discussed as a possible interim standard until such time as a perfect navigational aid was developed. The continued importance of Astro-Nav was also stressed. Lightweight search radar was mentioned as an item of standard equipment on new aircraft. A particularly interesting note was injected into the speaker's discussion on Astro-Nav when the new "Sight Reduction Tables" were mentioned. These tables eliminate several time-consuming steps previously followed and thus permit faster fixing. W/C Greenaway discussed the heading system in use today. He compared the well-known insufficiency of the magnetic compass with the increased accuracy of the gyro system, especially when the gyro is "free" (not slaved to the magnetic field).

During the question period at the conclusion of the paper, Captain Bower, USN, questioned the quoted gyro rate of wander in northern latitudes as compared with his own experience during operation "Deep Freeze" in the Antarctic. W/C Greenaway replied that, when the results were compared for both systems operating as free gyros, they seemed comparable. A discussion also took place with an overseas visitor regarding the feasibility of precomputed routes using prepared astro tables for fixing on each route. It was further suggested that future aircraft design would take into account the various antenna components necessary for improved self-contained navigational systems.

For the second paper, Mr. P. R. J. Reynolds of Pan American World Airways, ably assisted by Mr. C. L. Chandler, Meteorologist, gave an informative and highly interesting talk entitled "Flying the Jet Stream". Many coloured slides were used to aid the speaker with some very technical discussion. In particular, the make-up of a typical air mass surrounding the jet stream was well portrayed.

Actual accounts were presented of at least two flights flown deliberately using the forecast jet streams. The method of identifying one's position in respect to the jet stream by studying variations in outside air temperature was described and the speaker's thorough familiarity with the anatomy of the jet stream was remarkable.

In passing, it was noted that before the jet stream was truly discovered, an adverse high wind component occurring inexplicably was laid to navigational error during a fairly long trip. Forecast components of 100-150 kts were uncommon in yesterday's flying and allowance was not made for them. Of interest was the fact that an airline encountered a 250 kt component in the vicinity of Japan a short while ago.

The greatest change in navigational techniques over the last decade has been brought about by the use of the "least time" track instead of the fixed great circle and rhumb line tracks. A good example of this operation and its effect on other factors, e.g. weight and finance, is that a saving of 4 min in flight time, at the planning stage, is equal to 200 lb of fuel or the weight of one passenger and baggage.

During the question period, it was suggested that present traffic conditions on the North Atlantic routes prevented an in-flight change of flight plan to take advantage of jet streams. Mr. Reynolds replied that on only approximately 20% of the time was he refused such clearance and, if properly explained, the manoeuvre was frequently permitted by O.A.T.C. after a second request was made.

Finally, Mr. P. D. McTaggart-Cowan of the Department of Transport spoke on "Jet Weather" and gave an informative and highly interesting break-down of the meteorological operation and its function in relation to the airline dispatch office, past and present.

During World War II, in particular, this tightly-knit cooperation between

Navigation and Air Traffic Control Session: (l to r) Mr. P. R. J. Reynolds, Mr. C. L. Chandler, Mr. C. C. Bogart (Chairman), W/C K. R. Greenaway and Mr. P. D. McTaggart-Cowan

met-man, Operations office and pilot made many operations possible under almost impossible conditions.

Today the three components of this wartime team have moved further apart. The diverse types of aircraft that airlines are operating, combined with the inaccessible regions overflown, make very difficult any close cooperation between airline and government met-man. It is also a fact that aircraft are flying higher and farther and require much greater coverage than before. The resultant demands on the met-man's time have cut deeply into that previously allotted to personal contact. The speaker mentioned a possible answer to this problem. Pioneer airborne radio-teletype experiments are showing encouraging results and relieve the difficulties of interpreting voice and code broadcasts. This, in turn, benefits overworked radio channels and frequencies.

In conclusion, Mr. McTaggart-Cowan briefly touched on the jet streams and the increasing familiarity with which air crews and met-offices were treating this airflow. The speaker felt that any predictions that this phenomenon will eventually become a matter of academic interest to high flying jet transports and the met-man of the future are not well founded.

PROPULSION

Reported by R. G. Patterson

Mr. F. H. Keast acted as Chairman for this session on behalf of Mr. C. A. Grinyer, who was unable to be present owing to sickness. Mr. E. H. Higgins, Chairman of the Montreal Branch, extended a warm welcome to all C.A.I. and I.A.S. members visiting Montreal and said that local members were looking forward not only to an exchange of ideas but also to renewing friendships with friends from the USA.

Mr. P. Campbell introduced Mr. Shrader of the I.A.S. Mr. Shrader stated that this was the third year in succession that he had the pleasure of welcoming members to the Canadian meeting and that the I.A.S. had always tried to supply as much as possible towards the joint meetings and would continue to do so. He said it was nice to see everybody again and wished everyone good luck.

The first paper, entitled "Recent Advances in the Aerodynamic Design of Axial Turbomachinery", was presented by Mr. W. N. Robbins and Mr. H. W. Plohr of the NACA.

Mr. Robbins commenced the paper by stating that the current aircraft trend was towards higher flight speeds and that in order to advance the design of turbo-axial powerplants the aerodynamicist must of necessity be guided by mechanical requirements, these requirements being:

(a) Reliability
(b) Component weight
(c) Efficiency (and hence fuel consumption)
(d) The performance off the design point
(e) Design control.

It was explained that a typical turbojet engine contained, say, 16 compressor stages and 3 turbine stages, and that as a comparison it was desirable to decrease both the number of stages and the diameter whilst maintaining the same power output and component efficiencies. (The combustion equipment and other necessary engine components were not considered in this paper.) Now, the design velocity diagrams are controlled by Mach number and pressure ratio, whilst the mass flow is a function of inlet Mach number and rotor hub to blade tip ratio. Also, a blade tip speed of between 1,000 and 1,100 ft/sec was taken as the limit.

For a conventional subsonic compressor, hub to tip ratios were limited to approximately 0.5. However, for a supersonic compressor, the hub to tip ratio is increased to 0.7.

It was emphasized that stress considerations, although not specifically presented in the paper, were an underlying factor in the presentation being given.

Mr. Robbins briefly covered Preliminary Design considerations, reliability, component weight, efficiency, off design performance etc., demonstrating by the use of slides typical points, such as equivalent weight flow per unit frontal area in relation to inlet axial Mach number for various hub to tip diameter ratios, also the relation between inlet air flow and angle for various axial Mach numbers.

It was stated that the maximum mass flow is obtained when the axial Mach number is 1 and that the Mach number is limited primarily by choking considerations not in the annulus but in the blade row itself, as a result of which axial Mach numbers are usually restricted to 0.7 or less, in order to avoid the losses normally associated with choking in a blade row.

The effect of Mach number and blade loading on pressure ratio were demonstrated together with the effects of Mach number and efficiency for a conventional fixed geometry subsonic compressor operating over a range of speeds.

It was indicated that efficiency drops off rapidly after a relative Mach number of 0.7 to 0.8 is reached and that design tendency is to sacrifice pressure ratio in order to maintain efficiency, hence the aerodynamic problem consisted of trying to extend the Mach number range without losing efficiency.

The supposition was that efficiency fall-out was due to a combination of high Mach number and high blade loading rather than the shock losses associated with supersonic velocities alone. Thus a blade loading parameter, given in terms of the relative velocity across the blade

row, the change in tangential velocity and the blade solidity, was evolved. The loading parameter is termed the "diffusion factor" which has limiting values of 0.3 to 0.4 (for the rotor tip) above which efficiency deteriorates. Mr. Robbins stated that a single stage transonic compressor had been designed and built employing a "diffusion factor" in the region 0.3 to 0.4 and that without the use of inlet guide vanes a stage pressure ratio of 1.48, with a maximum airflow per unit frontal area of approximately 30 lb/sec, was obtained at a peak efficiency of 0.9.

This constitutes a mass flow increase of approximately 20%, and two conventional subsonic compressor stages would be required in order to produce the same pressure ratio.

The blade profiles selected for use in the transonic compressor were selected from a family of double circular arc aerofoil sections, the leading edge of which is thinner than usual, and the position of maximum thickness shifted towards the trailing edge as compared with conventional subsonic aerofoil sections. Mr. Robbins indicated that the same underlying principles of compressor design could be extended to turbine design and demonstrated the relation of local axial Mach number to pressure ratio as a controlling factor in turbine work output. The axial Mach number in the annulus being limited to about 0.7 in order to avoid the decrease in efficiency associated with the shock losses encountered at high relative exit Mach numbers.

Mr. Robbins concluded his paper by briefly summarizing the primary design objectives of axial flow turbo-compressors and stating that by using a transonic compressor and a suitably matched turbine the ratio in a particular case of, say, 16 compressor stages to 3 turbine stages could be reduced to 8 compressor to 2 turbine. Discussion following the paper consisted of one question, asking if any complications arose using the method outlined when multistage assemblies were considered. Mr. Robbins replied stating that for security reasons he was unable to say anything except that tests so far carried out by NACA had been satisfactory.

"Gas Turbine Combustion System Design" was the title of the second paper, which was presented by Mr. F. D. M. Williams of Orenda Engines Ltd. Mr. Williams introduced his subject by stating that his paper covered the design rules and simple analytical approach which had been used for the preparation and evaluation of the combustion system used in an advanced type of turbojet engine.

The essential dimensions of a new engine were arrived at by the designers in conjunction with the aerodynamicists, stress department and combustion engineers, the combustion system being controlled by the space available which, in turn, was dictated by shaft diameter, engine frontal area, air inlet diffusion length and acceptable levels of combustion intensity.

The combustion system must, of necessity, have a reasonable initial life and performance during early engine running in order to avoid compromising the development programme.

The combustion chamber maximum cross sectional area having been fixed, Mr. Williams demonstrated with the aid of slides how an inlet air velocity of approximately 120 ft/sec was arrived at in conjunction with the Pressure Loss Factor, and stated that since future velocities of between 170 and 200 ft/sec would have to be catered for, Pressure Loss Factors of 9 to 10 were envisaged.

The combustion intensities in the chamber were discussed and the interesting comparison between the combustion intensity of a conventional oil fired boiler and a present day aero engine combustion chamber made. The oil fired chamber had a value of 2.51 lb/hr/ft^3 whereas the aero gas turbine combustion chamber was about 200 lb/hr/ft^3. The relation between the combustion intensities, efficiency and stability range for a given pressure loss and outlet temperature distribution were demonstrated and led a description of the various designs of combustion chamber and the blade temperature distribution. The annular vapourizing combustion system had been chosen for the particular engine concerned.

The air flow division and velocities at entry to the chamber were chosen to provide the desired mean temperatures at outlet, whereas velocities within the chamber were arranged to avoid excessive pressure losses and allow skin cooling of the chamber to hold the temperatures down to 800°C. A seal having a positively controlled leakage rate at the downstream end of the chamber was used to control blade root temperatures.

Finally, calculation of transit time and the various Pressure Loss Factors for the chamber was made and the results compared with measured values in order to ensure that operation of the chamber was within the originally specified limits.

Mr. Williams stated that it was necessary to carry out rig testing on the combustion chamber design at least six months in advance of the first engine. The tests must cover the full range between start up and relight at high altitude, simulating all possible flight conditions. The relighting problems were becoming more acute with supersonic airflows wherein the inlet velocities were being more than doubled. Oxygen injection for relighting at high altitudes was now becoming an accepted method for heights between 30,000 and 65,000 ft.

The mechanical reliability aspects of chamber design were covered briefly, also the design requirements for future combustion chambers, in particular the meeting of the requirements of high

Propulsion Session: (l to r) Mr. F. H. Keast (Chairman), Mr. F. D. M. Williams, Mr. H. M. Weber, Mr. W. H. Robbins and Mr. H. W. Plohr

combustion efficiencies and outlet temperature distribution over wider ranges of inlet velocities and temperatures, and the problem of skin cooling when compressor outlet temperatures exceed 800°K.

The following questions and answers formed the discussion which followed the reading of the paper:

Q. How would you arrive at what constitutes a satisfactory Pressure Loss Factor?

A. In the first place, from experience. To achieve the projected combustion performance, a PLF of about 18 is indicated by present experience; for subsonic performance this would give a satisfactory pressure loss of the order 5 to 6% of compressor delivery total pressure.

Q. What comments had Mr. Williams on the use of aluminum tri-methyl as an ignition source at high altitudes, since claims had been for this fluid in the USA that satisfactory ignition had been obtained up to 120,000 ft?

A. Aluminum tri-methyl may well be used in the future, but for the present oxygen was more satisfactory from the viewpoint of supply and handling.

Q. What type of combustion system was preferable, can type or annular?

A. The vapourizing burner in general lends itself to annular chambers. However, because of the circular form given by a spray burner, there was a tendency to use the can type chamber as yet.

Q. What controls the maximum diameter of the engine, the compressor or the combustion system?

A. Using a compression ratio in the region of, say, 8 to 1, the combustion equipment was the controlling factor, but at 12 to 1 compression ratio either the turbine or the compressor become the controlling factor; however, once again this is related to combustion chamber gas velocity limits. (This answer may be debatable in the light of the information given in the first paper – R.G.P.)

Mr. H. M. Weber of the General Electric Company gave the concluding paper of the session, entitled "Power for Man's First Space Venture". He started by saying that since the advent of Sputnik 1, he was compelled to change the title of the paper to read "Power for the U.S. First Space Venture" and that the Russians had solved many problems, not the least of these being power.

In the US Vanguard project, the power requirement was that of raising a 20 lb satellite (21½ lb) to a height of 300 mi, with an orbital velocity of 18,000 mph from an initial weight of 11 (US) tons. This was to be achieved by a three stage rocket, 60 to 70 ft long.

The first stage was to take the rocket to an altitude of 40 mi at a final speed of 3,000 mph, the second stage to 300 mi at a final speed of 9,000 mph, whilst the third stage would accelerate the satellite in its orbit to 18,000 mph.

Mr. Weber proceeded to describe with the aid of coloured slides the powerplant of the first stage of Vanguard, which is the General Electric 405X rocket motor giving a 270,000 lb thrust for 140 sec. The rocket motor fuels were liquid oxygen and kerosene, these being pumped under pressure into the combustion chamber by a turbine pump driven by the decomposition products of hydrogen peroxide and oxygen. The kerosene was circulated in the combustion chamber wall as a cooling agent prior to injection and a pyrotechnic igniter fired electrically was used for starting.

Some of the problems associated with the project could be envisaged when it was realized that the liquid oxygen entered at –300°F whilst the turbine was being temperature soaked at 1200° to 1300°; also the mixing of fuels and lubricants would result in explosion. Injector burn out and burning of the inner shell of the combustion chamber were also problems in that temperatures up to 5500°F were recorded.

Mr. Weber concluded his lecture by stating that their object in getting a satellite in orbit was to obtain an unobstructed view of space to examine the sun's spectra and the earth's magnetic field etc.

The discussion which followed the lecture is given in the form of questions and answers:

Q. If the payload is doubled, what are the thrust requirements?

A. The thrust requirement is doubled.

Q. Is the thrust axis considered a part of the powerplant?

A. The motor is gymboled through 10° and supplied with fuel via flexible hoses. Gymbol actuators are vehicle responsibility.

Q. What is the seal design and materials?

A. Not allowed to say.

Q. What troubles had G.E. with corrosion?

A. They found cleanliness of all aluminum parts to be the most important factor in preventing corrosion.

Q. Had G.E. experienced heat soaking causing coke up and also affecting heat transfer in the combustion area during a second run on ground test of a rocket motor?

A. No trouble had been experienced so far, probably due to the fact that the oxidizer was shut off first.

Dr. G. N. Patterson (right), W. Rupert Turnbull Lecturer, shaking hands with the President, G/C H. R. Foottit, after receiving the scroll

Conclusion

The speakers made excellent work of reading their papers considering the time available. Mr. Williams, in particular, read his well-detailed and extensive paper on gas turbine combustion chamber design in the short space of forty minutes. All the papers sustained a large audience, there being over 140 in attendance for the first two papers and a considerably greater number for the third paper.

Afternoon Session, October 21st

W. RUPERT TURNBULL LECTURE

Reported by Dr. E. Bendor

At a time when much newsprint is being devoted to the subjects of space flight and rocketry, this third W. Rupert Turnbull lecture entitled "Aerophysical problems of flight at extreme altitudes and speeds" and delivered by Dr. G. N. Patterson of the Institute of Aerophysics, Toronto, was indeed a memorable occasion. A large and appreciative audience reflected both the reputation of the lecturer and the timeliness of the subject.

Dr. Patterson was introduced by the Chairman, Dr. J. J. Green, who outlined the speaker's career in aeronautics – pursued across three continents and culminating in his appointment in 1949 as Director of the Institute of Aerophysics. This lecture was on a subject, or rather a number of subjects, which have occupied much of the Institute's attentions during the last few years.

Dr. Patterson began his lecture by discussing the practical range of applicability of the subject, showing how speed and altitude are related by the conflicting requirements of limited surface temperature and sufficiency of lift for sustained flight. He then proceeded to outline and discuss the various flow regimes, passing from supersonic to hypersonic, slip flow and free molecular

flow, which are contained between what is now conventional aerodynamics and the study of travel in vacuo. These studies of motion in rarefied gases, in which the mean free path of the gas molecules is appreciable in relation to the dimensions of a body in the gas, have been collectively called "superaerodynamics" by Zahm, Tsien and others. It became clear from Dr. Patterson's remarks that here was a vast new field of theoretical and experimental investigation, involving phenomena, such as ionization and dissociation, which are as yet little understood. Dr. Patterson repeatedly stressed the significance of these factors.

It was of course not possible for the lecturer to do much more than touch on many of the significant points, but his remarks served to remind the audience that the study of these extreme regimes of flight consisted of more than a mere extension of existing techniques, in the sense in which compressible flow studies are an extension of incompressible cases. Dr. Patterson's account illustrated with great force the underlying unity of the physical sciences.

In the latter part of his talk, the lecturer dealt with the various test techniques available for the investigation of flows at extremely high speeds and temperatures. The shock tube is the most important apparatus available. The audience seemed amazed to hear of tests in which the flow was fully developed for only fractions of a millisecond. Instrumentation capable of recording results in these short intervals of time is quite feasible, however, and much useful information can be obtained.

Difficult as it was to digest so much material in so short a time, many new possibilities arose before the imagination as Dr. Patterson outlined various phenomena. For example, the flow of ionized fluids may be regarded as a body force problem (like free convection flows). There exists the possibility of creating suitable flow fields by magnetic means, and the positioning of shock patterns and regions of high temperature by similar means might be a practical possibility. The study of magneto-aerodynamics is still in its infancy.

Dr. Patterson presented about 60 slides in support of his narrative. To end the lecture, he "could not resist", as he put it, showing his last slide depicting a space vehicle silhouetted against what appeared to be an extra-galactic nebula. Nor could the meeting "resist" being stirred by his faith in the future of astronautics. Dr. Patterson was no skeptic here and made a positive plea that aeronautical engineers acquaint themselves with the work of astrophysicists and astronomers, which they will soon be called upon to use in meeting the design problems of the future. Remarks of this order must surely have found a response in the enthusiasm of Dr. Patterson's audience.

It is not the custom of the Institute to hold a discussion after the W. Rupert Turnbull lecture and, indeed, a discussion would have been an anti-climax. Instead, the Chairman called upon Professor Loudon to propose the vote of thanks to the lecturer. His amusing recollections of Dr. Patterson's early experiments at the Institute of Aerophysics were a reminder that, in these days of technology on a national and sometimes even international level, there is still a place for the fundamental worker in the small laboratory; that weight of numbers and resources are not always a substitute for individual talent and devotion.

The President, Group Captain Foottit, made a presentation to Dr. Patterson, after which the session ended. It had been a very stimulating afternoon.

Morning Sessions, October 22nd

(Two Sessions running concurrently)

SPECIAL TECHNIQUES

Reported by K. W. Kimber

The Chairman for this Session was Mr. R. D. Hiscocks of De Havilland Aircraft of Canada Ltd. Three papers were read, entitled: (1) Stability and Control Characteristics of the Vertical Altitude VTOL Aircraft, (2) Simulated Flight Training – Its Uses and Limitations, and (3) Standby Rocket Engines for Civil Aircraft.

The first paper was given by Mr. E. R. Hinz of the Ryan Aeronautical Company and discussed the stability and control characteristics of the experimental Ryan X-13 VTOL aircraft powered by a Rolls-Royce turbojet engine. The success of the control system used on this aircraft was amply illustrated by a film shown after the paper was presented, with transition from vertical to horizontal flight and vice-versa being accomplished with apparent ease.

Although not specifically designed for high speed flight, the X-13 configuration was evolved with this aspect in mind. The delta planform was chosen basically because it provides a stable pitching moment up through maximum lift combined with a mild symmetrical stall. In addition, the trailing edge controls of a delta remain reasonably effective up to large angles of attack. In the transition and hovering stages, control in pitch and yaw is effected by deflecting the main jet, and control in roll by means of auxiliary wing tip jets using compressor bleed air.

Three axes stability augmentation is used to assist the pilot and Mr. Hinz described the type of augmentation system that might be used and showed flight

Special Techniques Session: (l to r) Mr. E. R. Hinz, Mr. G. E. Rice, Mr. R. D. Hiscocks (Chairman), Capt. D. J. Woodard, Mr. H. Burgen and Capt. G. B. Lothian

records which demonstrated how the system follows up the pilot's demand. Graphs were shown which indicated that the control available for manoeuvring during transition is more than adequate.

To keep the airborne weight to a minimum, virtually all the landing and takeoff provisions remain on the ground in a mobile service unit. This mobile service unit is essentially a platform which can be rotated hydraulically from a horizontal to a vertical attitude.

The second paper was given by Captain G. B. Lothian, Superintendent of Flying in the Flight Operations Dept. of Trans-Canada Air Lines, who commenced by indicating the tremendous increase in the cost of training flight crews between 1938 and the present day. He went on to describe the various synthetic trainers, of which the "Link" is probably the most well known, and demonstrated how they can be used to ease the situation. Training in the air ties up aircraft which could be used for more profitable tasks and puts considerable strain on the organization.

With the advent of the more complicated "Flight Simulators", the attitude of the government officials responsible for the pilot checks has changed, such that in the USA, for example, the regulations have been altered to permit one of the two annual checks to be done in a simulator. It is important, however, that the experienced airline pilot views the simulator as an opportunity to raise his professional standard.

Capt. Lothian stated that TCA feel that the simulator should reproduce the feel of the actual aircraft as much as possible, incorporating movement, "g", noise etc. It is possible, at present, for instance to finish the approach and landing visually using closed circuit TV and a projector mounted above the cockpit. In this way, landings can be practised at all airports.

In conclusion, Capt. Lothian showed that over a 10-year period, savings of almost $2 millions could be realized by using a simulator to train crews for the DC-8.

After the presentation of the paper, the question was raised as to who should be responsible for building the simulator. The questioner suggested that it should be the airframe manufacturer, who should also deliver the simulator sufficiently before the aircraft to enable crews to be trained. Capt. Lothian pointed out that the airframe manufacturer would not be likely to have the necessary specialization to do this, but emphasized that there should be complete cooperation between the airline, aircraft manufacturer and simulator manufacturer. In reply to a further question, he stated that TCA's approach to the problem posed by the pilots' suspicions of the simulator was to use as instructors experienced airline pilots, who had for some reason lost their medicals. However, there are only a few of these and in the future trained operators will have to be used.

The third paper was given by Mr. G. E. Rice, Manager of the Commercial JATO Sales, Aerojet-General Corporation. Mr. Rice commenced by outlining how aircraft performance could be improved, particularly in the one-engine-out climb and all-engine landing-climb cases, using standby rocket engines. He illustrated by means of photographs and tables how the all-up weight of the DC-3 aircraft could be increased by about 1,000 lb and still meet CAR 4b requirements, by adding 2 standby rocket engines. Of this increase, about 800 lb would be payload.

Various methods of installation have been used, both flush and external. The effect of the external installation on aircraft performance has not been measurable. In recent years, several aircraft have crashed on mountain tops. If standby rockets had been installed, these crashes probably would not have occurred.

In conclusion, Mr. Rice stated that the cost of installing and carrying the standby rockets would be easily covered by the average addition of one passenger or 200 lb of mail in the first year, and in succeeding years would be much less.

The Chairman, Mr. Hiscocks, thanked the speaker and remarked that "unfortunately it looked as if the DC-3 would be with us for years". Mr. Rice stated that by using standby rockets, it should be good for another 15 years. Questioned as to the merits of the rockets vs small turbines, he stated that 11 aircraft could be equipped with rocket engines for the same cost as 1 with turbines.

EDUCATION AND TRAINING

Reported by A. C. Holden

This Session was devoted to an informal discussion on the topic of "The Shortage of Technical Personnel". The Moderator of the Session was Professor T. R. Loudon, retired Head of the Department of Aeronautical Engineering, University of Toronto, and now Assistant to the Chief Engineer and Director of Training, De Havilland Aircraft of Canada Ltd. Members of the panel included Dr. C. D. Perkins, Chairman, Aeronautical Engineering Department, Princeton University, recently returned from a year's assignment as Chief Scientist, USAF; Mr. W. H. Arata, Jr., Chief Operations Engineer, Fairchild Aircraft Division; Mr. W. A. B. Saunders, Vice-Principal, Provincial Institute of Technology and Art, Calgary; Mr. B. W. Torell, Supervisor, Engineering, Trans-Canada Air Lines, Winnipeg, who was called in at the eleventh hour to fill in for Mr. A. E. Ades, also of TCA, originally scheduled.

The purpose of the meeting was twofold; first, to determine whether or not there really was a shortage of technical personnel; and second, to determine what was being done or should be done to alleviate the shortage of technical personnel. The attendance of 85 persons from industry, educational institutions and the Services indicated a considerable interest in the subject. Prof. Loudon introduced the four speakers of the panel without ado.

Dr. Perkins felt that, in the USA at least, the demand for engineering and technical personnel has changed drastically in the past few years. He felt that the impact of the ICBM program was tremendous and has been a major reason for the shortage of technical personnel since 1954. He said that firms intending to bid on the project had to show that they had a competent technical staff and, therefore, did considerable hiring regardless of current requirements. A number of firms also attempted to hire from Universities and this, in fact, could have almost wrecked the educational program and resulted in even more of a shortage. However, an alternative scheme was devised whereby many professors became consultants to industry on a part-time basis but retained their educational posts. Dr. Perkins felt the defence cutbacks, caused mainly by budgetary considerations within the last year or so, have completely changed the picture again. For example, the cancellation of the Navaho project released immediately six thousand people involved at North American. This did not mean that other firms were able to hire very many highly technical people from North American, but rather that North American assigned them to other projects and would themselves cease to seek engineers from the outside. Dr. Perkins clearly pointed out that the good men were always kept but there is now no field day for the less capable engineering and technical personnel. Further, Dr. Perkins feels that with the increasing complexity of the modern weapons system, there is a greater need than ever before for "engineering scientists" with M.Sc. and Ph.D. degrees. He indicated that there is considerably less need now for B.Sc. degree people and this is shown by the fact that salaries offered B.Sc. graduates are now beginning to level out. At his own unversity, Princeton, the brightest young men are encouraged to carry on

Education and Training Session: On the left is the panel consisting of (l to r) Mr. W. A. B. Saunders, Mr. B. W. Torell, Prof. T. R. Loudon (Moderator), Mr. W. H. Arata and Prof. C. D. Perkins. On the right, discussion from the audience

towards at least an M.Sc. and there are many fellowships and assistantships to aid them. In fact, Dr. Perkins concluded, there is an actual shortage of qualified applicants for this assistance.

Mr. Arata of Fairchild was then introduced. Mr. Arata considered mainly what was being done by the I.A.S., industry in general, and by his own company, Fairchild, to meet the engineering shortage. He pointed out that the I.A.S. was active at a university level to encourage students in the engineering field. As an example, he cited the Student Regional Conferences being held from coast to coast under the auspices of the I.A.S. with the various aircraft companies as hosts, as well as the vocational guidance literature being distributed by the I.A.S. to universities and high schools. He also pointed out that many scholarship programs were being offered by industry and also model contests and films were used to stimulate interest in engineering in general and aviation in particular. He said that Fairchild Aircraft, for example, participates in closed circuit educational TV through the local schools in Washington County, Maryland, and included vocational guidance information. In conclusion he felt that the efforts could be extended even to the grammar school level in the future. Mr. Arata's talk was well illustrated with appropriate slides.

Mr. Torell of TCA was then introduced. Mr. Torell felt that, while the shortage of technical personnel was being alleviated somewhat, there was still a great shortage in the technical field below the engineer level and above the mechanic level, mainly in the technician-technologist level. He further felt that, regardless of defence requirements, the many new gadgets now being developed for household and industrial use will continue to create a great need for technical personnel. Mr. Torell attributed the shortage at the technical level to the following:

(a) Salaries in the teaching profession are low and, therefore, there is a shortage of teachers.

(b) Cost of education is high.

(c) It is difficult, in some cases, to attract qualified students.

(d) Prestige in the technician field is not high enough.

(e) Monetary recognition is not sufficient, particularly for those with considerably more experience.

(f) Many engineers are being used to do technicians jobs.

Mr. Torell felt that industry should review curricula offered by educational institutions and should communicate their needs to these institutions. He also thought that there needed to be a clearer definition of the technician grades in the engineering field. A vote of thanks is due to Mr. Torell for his fine presentation on such short notice.

Mr. Saunders of the Provincial Institute of Technology and Art was the next speaker. Prior to his present assignment as Vice-Principal, Mr. Saunders was Head of the Aeronautical Department of the Institute. Mr. Saunders agreed with Dr. Perkins that there was a great shortage of M.Sc. and Ph.D. level personnel but he also agreed with Mr. Torell that there was a real shortage in the technician level. Since Mr. Saunders was more concerned with training students for the technician level, his major consideration was this problem. Mr. Saunders pointed out the need for definition of the technician. There is always the problem of where does the mechanic's work stop and the technician's work begin, and where does the technician's work stop and the engineer's begin. In Ontario, Mr. Saunders said, the Professional Engineering Association has defined two levels of technologist and three levels of technician positions to cover this field and answer this question. Mr. Saunders feels the proper use of technician-technologists could end the need for mediocre engineers and allow engineers to take their proper place, performing true engineering work. Mr. Saunders felt that there should be a higher proportion of technicians to engineers and that this would do much to meet the high demand for engineering personnel.

The meeting was then opened for general discussion, which turned out to be quite spirited. The feeling was prevalent that the educational bodies were willing to go more than half-way to meet the demands for industry and in setting up programs to meet industry's latest requirements. However, as Prof. Loudon pointed out, education could go only so far. In his opinion, the duty of education is to train men to *become* engineers and technicians, and it is the duty of industry to train men to *be* engineers and technicians. Dr. G. N. Patterson, Director of the Institute of Aerophysics at the University of Toronto, suggested that in many instances industry tended to forget young student engineers employed for the summer. He said that frequently the summer employee, even though he had completed most of his education or even graduated from university, is frequently given technician's work and that these students come back to him in the fall with a serious question

Space Vehicles Session: (l to r) Dr. G. Herzberg, Mr. H. Cohen, Dr. J. E. Keyston (Chairman), Mr. G. H. Tidy, Dr. G. V. Bull and Dr. K. R. Enkenhus

in mind about whether or not they wanted to become engineers. He also indicated that there was still a great demand for B.Sc. engineers at the University of Toronto.

One member of the audience pointed out that we might be able to help alleviate the engineering shortage if we made better use of European immigrants. He felt that some of these immigrants were not given full engineering responsibilities and, in many cases, had to work at a level far below their capabilities. Another comment was that Management should look closely at its own engineering staff with a view towards better utilization of existing personnel. An engineering student present felt that educational institutions could help ease the shortage by offering more evening courses eventually leading to degrees in engineering.

In conclusion, it seemed to be generally agreed that, while the engineering shortage was diminishing somewhat, perhaps due to cut-backs in defence expenditures, the shortage nevertheless still exists, particularly at the technician-technologist level and at the M.Sc. and Ph.D. level. However, there was still a great demand for B.Sc. level people as well, particularly in Canada. There was also the feeling that the steps now being taken to meet the demand should be pursued more vigourously than ever.

Afternoon Sessions, October 22nd

SPACE VEHICLES

Reported by O. E. Michaelsen

Tuesday afternoon's Session, entitled "Space Vehicles", got under way at 2.10 pm under the Chairmanship of Dr. J. E. Keyston of the Defence Research Board. The large attendance, estimated to number 150 people by this reporter, suggested that the occurrence of "Sputnik" had stimulated the interest of a great many groups within the aeronautical field.

Following some general opening remarks, Dr. Keyston introduced, as the first speaker of the afternoon, Dr. G. Herzberg, Director of the Division of Pure Physics of the National Research Council. Briefly reviewing the speaker's impressive career, the Chairman concluded that Dr. Herzberg was indeed a well qualified authority on the subject of his paper "Composition of the Upper Atmosphere".

The speaker commenced by pointing out the reasons for the increasing interest in the upper atmosphere and outlined how we can obtain information about the composition of this region. This information, together with details of pressure and temperature variation, may be derived from theoretical prediction, analysis of the solar spectrum, the emission spectrum of the aurora and of the "night-glow" or "twilight-glow" spectrum, together with information obtained from radio wave propagation and direct air sampling by rockets.

Contrasting the characteristics of an idealized (isothermal) atmosphere with those of the actual one as observed by various methods, Dr. Herzberg explained that the atmosphere can be considered to consist of different regions, the composition and temperature distribution of which vary considerably from one to the other. He then went on to discuss in detail the reasons for these differences and presented evidence of such phenomena as diffusive separation, photochemical processes produced by solar radiation, and collection of interplanetary gas by the atmosphere as the earth moves around the sun.

The presentation was supported by a number of slides showing tables, graphs and spectrum photographs. Dr. Herzberg also made use of the blackboard on several occasions in spite of experiencing repeated difficulties with the wiring of the public address system.

It appeared that such a comprehensive paper was too technical to stimulate much discussion from an aeronautical audience.

The second paper, entitled "Project Vanguard – A Report on Progress" was given by Mr. H. Cohen, Vanguard Quality Project Supervisor of the Glenn L. Martin Co. The speaker first outlined the advantages of the satellite as a scientific observation platform, compared with the relatively short duration sounding rockets of the Viking category. An historical account of the conception and growth of the project and its connection with the I.G.Y. followed. The speaker then went on to describe briefly the three stage launching vehicle and its associated rocket powerplants, the stability and control system of each stage and also the flight trajectory which the rocket will follow in order to establish the satellite in orbit.

Mr. Cohen then continued, describing the impressive program carried out to check and test the numerous components and systems of the launching vehicle. His description of the two successful test firings appeared to arouse particular interest.

The speaker concluded by describing the main difficulties experienced to date in the development of the launching vehicle and stated that all major components had individually come close enough to the desired specifications to warrant great confidence in the success of the final system.

The paper was accompanied by numerous excellent slides giving an account of the various phases of the ring, mock-ups component test and complete system testing.

A large number of questions from various quarters followed the presentation of the paper. Several of these remained unanswered by the speaker as they came under security classification. However, Mr. Cohen did confirm that the schedule for the launching of a 3 lb satellite in December of this year is in effect. He also stated that this satellite would not be instrumented.

The question was then raised as to why the Martin Co. was so concerned about the life of the rocket engines. The speaker pointed out that several static test firings may be carried out at the firing site if other components should malfunction or fail.

The most entertaining moment of the afternoon came when one of the questioners became concerned about the fate of the moon. He asked if there were any evidence that the moon was being slowed up by drag resulting from the presence of the interplanetary medium. A semi-serious discussion developed with the Chairman having the last word.

In answer to further questions, Mr. Cohen stated that the nose material of the rocket consisted of a laminated asbestos compound and that the Vanguard satellite had a high reflectivity and should, therefore, be more easily seen than the third stage of the rocket. The Chairman mentioned that one of the reasons why the third stage of the Sputnik rocket was more easily observed than Sputnik itself was due to the fact that the third stage passed over Canada at a more favourable time of day.

Mr. Cohen attributed the light weight of the Vanguard satellite to more efficient design of the instrumentation than that of Sputnik. He said that no attempt to recover the satellite would be made and that it would gradually slow up and burn in the atmosphere. He also stated that telemetry was installed for error checks during firing.

The Chairman introduced the last speaker of the afternoon by giving a brief outline of the work carried out at the CARDE facility. The paper, entitled "Exit and Re-entry Problems" was written jointly by Dr. G. V. Bull, Dr. K. R. Enkenhus and Mr. G. H. Tidy, all employed at CARDE. Dr. Bull presented the paper.

The speaker pointed out in his introduction that the paper was merely intended to illustrate some phases of general interest and current activity. He discussed the ballistic trajectories of missiles and some of the problems associated with the exit from, and re-entry into, the denser part of the atmosphere. The flight problems in regions of free molecule flow, slip flow and continuous flow were then considered in succession.

Dr. Bull outlined methods of laboratory simulation and the extreme difficulties encountered as a result of the large thermal energies required to simulate the appropriate temperatures involved. Intermittent helium wind tunnels and various types of shock tubes all have their severe limitations. Dr. Bull concluded by describing a hypersonic ballistic range facility under development by CARDE.

The presentation was accompanied by about a dozen slides of which the multi-coloured graphs were particularly appreciated for their lucidity.

Dr. Bull, in response to a question following the paper, answered that the effect of the missile re-entry angle could be studied in the range by the firing of missiles of various shapes. Mr. Tidy said that very low densities could be obtained in the range and Dr. Bull concluded the question period by stating that the range of shapes that could be studied was limited by the high accelerations experienced during the firing.

Mr. Britton, Vice-President of the C.A.I., thanked the audience for contributing to a highly successful meeting and declared the Meeting closed.

AIR-LINE OPERATIONS

Reported by D. S. Griffin

This alternative Session was held in the Brittany Room under the Chairmanship of Air Vice Marshal A. Ferrier, Assistant Secretary General, Air Navigation, I.C.A.O.

The Session included papers on air safety, the legal aspects of aircraft noise and projected helicopter operations in the New York area in 1960. Some 45 people attended. A fifteen minute discussion followed the presentation of each paper. It is regretted that the various participants in the discussions could not be identified for this report.

The Chairman opened proceedings promptly at 2 pm by welcoming the audience and introducing the first speaker, Mr. R. M. Woodham, Associate Director, Cornell Guggenheim Aviation Safety Center, who spoke upon "Important Factors in Aviation Safety".

Mr. Woodham covered a wide range of pertinent topics, the highlights of each being illustrated by an excellent series of slides, many so filled with data that they encouraged closer study than time permitted. Although primarily concerned with conditions in the USA, the facts presented were representative of all high-density terminal areas. These are some of them:

(a) It is necessary that an adequate system of air traffic control be developed in view of an expected doubling of commercial aircraft movements in the next twenty years.

(b) Studies have indicated that in ideal conditions, with a clear-air visibility of 14 mi, the average perception of pre-warned pilots flying collision courses is actually only 4-5 mi. Effective airborne anti-collision devices should give spherical coverage; the problems encountered in this connection involve cost, weight and size.

(c) It is essential that more attention be paid to "built-in" occupant protection rather than to stretching fastenings and attachments to the limit while providing more luxurious appointments and facilities which break loose on impact. One incident illustrated showed that aft-facing seats had proved no more protective than the forward-facing type. The importance of effectively placed ditching exits and the provision of crash rescue beacons for over-water operations was emphasized. Despite extensive NACA investigations into crash fire protection, now proven to be satisfactory for the penalty of 10 gals of water and associated plumbing per engine (see paper by Mr. I. I. Pinkel, Canadian Aeronautical Journal, December 1955, p 231), no transport aircraft has been so equipped to date.

(d) Attention was drawn to an estimated increase of 175% in private business aircraft by 1957 and the three main contributory factors to private flying accidents: adverse weather, spiral instability and inadequate instrument flying training.

(e) Various arrangements of airport runways were illustrated whereby traffic movements could be increased. The use of parallel runways at predetermined distances apart would double the number of movements per hour.

(f) Of 6,539 USA airfields currently in use, only 426 have weather service facilities. A proposed scheme for a nation-wide broadcasting network was presented. This would utilize 88 stations, each covering a radius of 250 mi. It was required that en route and airport temperatures be forecast within an accuracy of $\pm 3°$ and $\pm 1°$ respectively. The necessity for adequate airborne warning radar was illustrated by details of a DC-6 which suffered damage amounting to $450,000 while flying for one minute through a hailstorm.

Mr. Woodham also dealt briefly with the problems associated with the steady increase in jet aircraft operations and with the safety features inherent in the slower takeoff and landing VTOL type of aircraft.

The following are some of the points made in the discussion of Mr. Woodham's paper.

Member: In connection with occupant protection, would it be possible to design "weak links" into airplane structures so that breakages would occur at predetermined points, the remaining structure being designed over-strength so as to absorb impact loads? Further, could fuse-

lages be divided into self-contained compartments by means of strong structural bulkheads? These would not only avoid tube-like interiors but also prevent passengers and fixtures being hurled the full length of a fuselage. Concerning the private pilot, there is at present nothing to bring him back to the flying school until he applies for an instrument rating after 200 hours. Much of the lack of experience mentioned would be avoided if contact with the school could be maintained.

Mr. Woodham: Structural suggestions, such as these, would require very careful consideration by all concerned. It was essential that greater attention be given to interior fastenings, particularly seat fittings. The use of strong bulkheads appeared logical but would entail weight penalties and reductions in the available passenger volume. The introduction of a limited commercial license after 50-75 hrs would be an improvement. The present situation, whereby the private pilot must accumulate 200 hrs experience for his instrument rating – at a cost of between $2,000 and $2,500 – leads to possible infringements of the regulations. The pilot may be induced to fly for hire in order to recoup his expenses. It was understood that CAA were considering the introduction of what might be termed a senior pilot's license, obtainable after 75 hrs experience plus a demonstrated ability to handle an aircraft in adverse weather conditions. This would be an intermediate step before proving his proficiency in instrument flying.

Member: As a meteorologist, it appears practical that en route temperatures will eventually be predicted within $\pm 3°$. Other necessities were presenting problems, notably: airport temperature forecasts within an accuracy of $\pm 1°$; the accurate forecasting of en route winds (particularly jet streams) and en route turbulence; the prediction of associated free airway conditions, the accurate timing of actual weather closure at airports, and the more accurate prediction of icing conditions in place of the present indication of general areas in which icing could be expected.

Member: In the discussion of crash fire protection, no mention has been made of airport ground equipment for which international standards are in existence. The growing use of jet transport aircraft with their large fuel capacities would present a further hazard.

Mr. Woodham: Two out of three crashes on takeoff or landing occur more than five miles from an airport; the arrival of ground equipment can be delayed by distance and/or terrain. As adequate protection must be provided in the first few minutes, it is obvious that the necessary safety measures should be installed in the aircraft.

Airport equipment should certainly be on a scale sufficient to handle on-the-spot hazards, particularly in view of the large fuel tankages now anticipated with associated refuelling provisions capable of transferring 1,500 gals per minute.

Member: The I.C.A.O. is presently concerned with the increase in traffic density at major terminal areas and the attendant danger of less well-equipped aircraft flying in those vicinities. Would it not be possible to prohibit amateur pilots from using commercial terminals?

Mr. Woodham: Certain terminal areas (e.g. New York and Washington) are already restricted to aircraft possessing two-way radio equipment. Stringent regulations present a difficult problem in that the private pilot should enjoy the same freedom of movement as the car driver. All that can be said at present is that he should recognize his public responsibilities in the air in the same way as the motorist on the ground.

The second paper in the Session entitled "When is an Aircraft a 'Nuisance' in the Eyes of the Law?", was presented by Mr. A. R. Paterson, Solicitor, Blake, Cassels and Graydon, Toronto.

Although, in his own words, Mr. Paterson "had been at a loss for a subject of interest", his selection was not only timely in an age of ever-increasing noisiness, but it dealt with an aspect which has received remarkably little attention in the past.

Two types of nuisance are recognized in law – the public or common nuisance, which affects the public at large and is treated as a crime, and the private nuisance, which is a disturbance of a person's rights of property. Annoyance caused by the operating of an airport or an aircraft is likely to fall under the latter category.

Complainants must be owners or occupiers of property and must establish that damage has been suffered or that the quiet enjoyment of their property has been interfered with. In the latter case, it is not necessary to show physical damage to the property or person, although such evidence would be advantageous. Court decisions are made as a matter of fact on the evidence presented and are thus largely a matter of degree.

Although a court might hesitate to proclaim a nuisance in cases where public hardship or inconvenience would result from a discontinuance of the annoyance, such an argument would not constitute a defence. Neither would the fact that a person voluntarily moved adjacent to the annoyance, although such a situation would be viewed more circumspectly than one where the annoyance arrived after the property owners. However, if a statute is in existence which directs or authorizes the performance of the nuisance in specific terms, so that the act complained of cannot be performed in any other way, then a court would interpret the statute as being a defence.

No such statutes concerning aircraft exist in Canada; therefore, if a court decided that a nuisance had been committed, it would most likely grant an injunction against the operator. Recent litigation in the USA has indicated that, provided the operation of aircraft or airports comply with CAB Regulations, then no liability for damages or granting of an injunction can be made. This situation is likely to be clarified as a result of cases still pending.

Legislation concerning aircraft in flight or on the ground has been in existence in the United Kingdom since 1920 and the onus for holding a balance between private and public interests has been placed on the Minister of Transport and Civil Aviation.

Mr. Paterson concluded by suggesting that the problem should be discussed between government, manufacturers and operators so that reasonable protection from actions for nuisance can be given pending the introduction of effective silencing devices.

The following are some of the points made in the discussion of Mr. Paterson's paper.

Member: I was a little shocked to learn that legislation virtually allows the nuisance instead of defining permissible noise levels.

Mr. Paterson: In general, measures have not been taken at the manufacturing level, probably due to the required efficiency of military aircraft. Neither have operators brought sufficient pressure to bear. The solution may lie in compromise, even to the extent of compensatory payments to those living adjacent to airports. However, it is unlikely that offending aircraft would be taken out of service and any necessary pressure upon the aircraft industry may have to be applied from political levels.

Member: It appears that a quantitative determination of the term "quiet enjoyment of property" is required. The disturbance in the proximity of airports is likely to increase with jet aircraft. How can such a determination be arrived at?

Mr. Paterson: Whether or not there has been a nuisance has to be decided as a matter of fact on the evidence presented. The twelve jurymen would most likely be unable to decide on technical evidence involving decibels and would try to determine whether the disturbance was normal or excessive. In this respect, a noise level considered reasonable today

Air-line Operations Session: (l to r) Mr. R. L. Cummings, Mr. R. M. Woodham, A/V/M A. Ferrier (Chairman) and Mr. A. R. Paterson

would most likely have been intolerable yesterday. The increase complained of would probably be in the frequency range rather than in volume; therefore, a jury could find in favour of the complainant, but verdicts might necessarily vary. Such a possibility should be balanced out by government agencies, although there have been little signs of such action as yet.

Member: It is hoped that the new jet transports will not be any noisier than aircraft presently in service due to new climb out procedures etc.

Member: Jet noise is actually in the lower frequency range, except in the compressor stages; hence there should be an advantage.

Mr. Paterson: That may be so, but it certainly *seems* to be higher.

Member: There could be a rash of lawsuits in the USA and UK from opportunists. Could these be sorted out by an assessment of damage?

Mr. Paterson: Damage largely results from shock waves. In this connection, there are rules in the UK which restrict breaking the sound barrier to heights above 30,000 ft. Certain voluntary payments have been made but there have been no admissions of liability. People have been active around London Airport and it is extremely difficult to prove whether or not jerry-building is actually responsible for property damage. The solution seems to lie in the creation of a Claims Commission and placing the problem into the hands of the Minister of Transport.

Member: Not everyone is concerned with a "fast buck"; they are more concerned with an abatement of the noise. It is not a question of decibels but rather the message conveyed to the senses by the noise.

Mr. Paterson: Serious inconvenience and damage can be caused, but it must be remembered that dwellers by railway tracks cannot rightfully complain about excessive whistling owing to the existence of statutory authority for running trains on those tracks.

The third and last speaker, Mr. R. L. Cummings, Jr., President, New York Airways Inc., presented a paper entitled "Scheduled Helicopters—The Year 1960".

With the aid of curves and diagrams, Mr. Cummings traced the four year history of his company, one of the four currently operating scheduled helicopter services. Anticipated progress up to the mid-1960's was presented. It was predicted that by 1960 a 20-25 passenger, multi-turbine powered helicopter, having a range of 125 mi, would be available. This machine, designated Ship "X", would be an intermediate step before the expected development of a 250 mi range, 50 seat helicopter. Details were presented which showed a fleet transition from the 5-7 seat S-55 (dependent upon floatation gear and other installed equipment), through the 12-seat S-58 to the Ship "X". Pertinent operating data from 1953 to 1965 were tabulated in a detailed appendix to the paper.

It was confidently expected that between 1962 and 1965, with five to ten Ship "X's" in operation, the company would become freed from government subsidy. Five such machines, operating within a 25 mi radius of the heart of New York City, would have a daily utilization involving 250 landings spread over 3,000 mi of flying. Revenue estimates predicted a reduction in the yield per passenger mile from the current 42 cents to 30 cents by 1962. In that year, with five machines, it is expected that one million passengers will be carried with a revenue exceeding four million dollars. Expansion to ten Ship "X's" would more than double both estimates. Traffic would be largely terminal to terminal between the three city airports and six heliports scheduled for construction by the Port Authority.

Mr. Cummings paid tribute to the assistance and cooperation extended to his company by fixed-wing operators and various Federal and civic agencies.

The following are some of the points made in the discussion of Mr. Cummings' paper.

Member: Do you carry, or intend to carry, co-pilots?

Mr. Cummings: Yes, we do employ co-pilots.

Member: Can you give particulars concerning Decca in precipitation static?

Mr. Cummings: Decca installed on our machines is shielded and carried underneath the ship.

Member: What has been the experience of your company concerning instrument flying?

Mr. Cummings: Our operations are exclusively to VFR because of the single engined feature. No instrument flying is projected as yet, although there might be possibilities with the introduction of the multi-turbined ships.

Member: From a rough calculation, it appears that the operating costs for Ship "X" will be 9½ cents per passenger mile. Can you give comparable figures for the S-55 and S-58?

Mr. Cummings: Details from which those can be obtained are given in Appendix A to the paper.

Member: Can you give details concerning the length of time required to train a fixed-wing pilot for helicopter flying and how the two training periods compare?

Mr. Cummings: All our pilots hold commercial ratings in fixed wing aircraft because of the high density traffic in the vicinity of our operations. This knowledge of fixed-wing procedures has prevented even one "near miss". The particulars you asked for could be obtained by writing our Operations Manager.

Member: You mentioned that the seating capacity of the S-55 was affected by a necessity for floatation gear.

Mr. Cummings: Such gear supplements the single engine because we are taking off and landing within 5 ft of the water. It consists of inflated sausages etc., but

has been taken off the S-58. It involves a loss of speed, 550 lb of dead weight and vibration on flare-out.

Member: Have you considered the possibility of using a rolling takeoff in order to assist in the carrying of a heavier load?

Mr. Cummings: Our normal procedure is to rise to 4 or 5 ft and then pick up altitude with speed; in other words, we go through the "dead man's curve". A rolling takeoff has not been projected as this is not the correct way to use a helicopter.

Member: Particulars have been published regarding the Westland with a Napier "Gazelle" engine, which would apparently give a quick airborne ability. Would this increase utilization?

Mr. Cummings: The details concerning this engine are very interesting and the answer to your question is "Yes". The advent of the turbine engine has meant the difference between night and day to helicopter people.

Chairman: I notice that you estimate a total of 80,000 passengers for 1957. Who are these people, what are they doing and why do they want to use helicopters?

Mr. Cummings: We conducted a survey which showed that they are mostly commuters crossing New York in order to make connections between the three airports. There is a general lack of sightseers. Our charter business is booked to capacity.

Member: Are you thinking in terms beyond Ship "X"?

Mr. Cummings: Nothing has yet been seen that can do what the helicopter can, particularly in the field of economy. We are adopting an open mind and have not excluded STOL and VTOL capabilities, but we think that the helicopter is the best bet for the coming five to eight years.

Member: Have you considered the use of rocket assistance at the blade tips?

Mr. Cummings: We would have no objection to such a scheme; the main problem is weight, already a critical consideration.

Member: The projected reduction from 42 cents to 30 cents per passenger mile would still be higher than the long range fixed wing aircraft. Would this continue to reduce or would the problems in traffic density lead to an increase?

Mr. Cummings: Our figures are based on operations within a 20 mi radius of New York Harbour. Helicopters will not exist on longer hauls without bigger ships. We will eventually have the problem of meeting 130 passenger jets. The 30 cent estimate does not take such larger ships into account.

Member: Is there any connection between the operating cost of 9½ cents and the revenue of 30 cents, per passenger mile?

Mr. Cummings: We envisage that revenue will permit operating at that level; we will also be out of the subsidy area in 1962.

At the conclusion of the Session, the Chairman called on Mr. Luttman, Secretary of the C.A.I. In closing the Meeting, Mr. Luttman thanked all those who had contributed – the Chairman, the Speakers and, in particular, the staffs from I.A.S. Headquarters and of the Montreal Branch.

Copies of Preprints of most of the papers given at this Meeting, other than the W. Rupert Turnbull Lecture, can be procured from

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SYMPOSIUM

THE first Symposium organized by the Institute was held on the 24th October, 1957, to consider "Foreign Objects in Aircraft, Engines and Airborne Equipment". It took place in the ideal surroundings of the R.C.A.F. Officers Mess, Ottawa; the acoustics were good, so that discussion could be carried on without microphones etc.; projector equipment was provided; the seats were comfortable (and easy to stand up from); and coffee, lunch and bar facilities were available. The subject was "kicked around" all day and a verbatim record was kept by court reporters supplied by the R.C.A.F. It is thought that the suggestions and ideas put forward are of sufficient general interest to warrant fairly detailed dissemination and, from the verbatim record, a full report is being prepared for publication in a subsequent issue of the Journal.

A framework of the discussion was provided by four short, prepared addresses delivered by A/C G. G. Truscott, Chief Aeronautical Engineer, R.C.A.F., Mr. A. E. Ades, Assistant Director of Engineering, T.C.A., Mr. D. P. Stowell, Vice-President, Manufacturing, Canadair Ltd., and G/C R. C. Hawtrey, Director of Maintenance Engineering, R.C.A.F. Mr. H. S. Rees, Chief Aeronautical Engineer, Department of Transport, was in the chair. A film and some slides of typical damage and foreign objects found in aircraft were shown, after the luncheon interval, by W/C P. de L. Markham. The attendance was 53 members and guests and of these 33 actually contributed to the discussion, a goodly proportion; probably they all had something to say about it, in twos and threes, at the bar and during lunch.

In the course of the meeting, it became evident that the three primary sources of trouble lay in:

(a) inadequate cleaning of runways and taxi-strips, resulting in the presence of stones and bits and pieces which caused extensive damage to propellers and, more seriously, turbojet engines;

(b) inadequate and widely varying colour and identification coding of fluids, such as fuels, lubricating oils, hydraulic fluids, cleaning solvents and the like; and

(c) just plain carelessness by people working on and flying aircraft, which was aggravated by poor detail design.

It was decided to ask the Air Industries and Transport Association to sponsor two committees, one to study and try to establish some degree of standardization of colour and identification coding of fluids, and the other to collect information on instances of damage, jamming and malfunctioning attributable to foreign objects and to compile a check list; this check list would be brought to the attention of manufacturers, who would be asked to ensure that their designs were examined by competent people to eliminate, so far as possible, all features vulnerable to this sort of hazard.

And, of course, the importance of education was stressed. Every organization has a responsibility for practicing good housekeeping, every individual in the business must develop tidy work habits and every detail designer must bear in mind that so long as aircraft are made and maintained and flown by men, things will be left about. As one speaker put it, lapses in these fields are not found out "until we bury someone".

MEMBERS

NEWS

D. F. Saunders, M.C.A.I., has resigned his position with Canadair Ltd. to join the Design staff of Vickers-Armstrongs (Aircraft) Ltd., England.

LCDR H. J. Sloan, M.C.A.I., has left the R.C.N. to join the Dept. of Defence Production as Technical Coordinator, Guided Missiles.

P. J. Waite, M.C.A.I., formerly with D. Napier and Son Ltd., has recently joined Rolls-Royce of Canada Ltd. in the Aero Sales Dept. where he will be identified with the Tyne turboprop engine.

J. H. Gruter, Associate, has resigned his position with Carriere and MacFeeters Ltd. to join the Purchasing staff of Canadian Applied Research Ltd.

Dr. W. R. Hossack, Technical Member, has left Avro Aircraft Ltd. to establish a consultant Operations Research service for Stevenson and Kellogg Ltd., Consulting Management Engineers.

D. R. Hennig, Student, recently graduated from the Institute of Technology and Art, Calgary, is now employed by Avro Aircraft Ltd. in the capacity of Engineering Assistant.

DEATH

It is with deep regret that we announce the death, on the 2nd December, of **G. M. Turner, M.C.A.I.,** Assistant Aviation Manager of the Railway & Power Engineering Corporation. Mr. Turner was well known to many in the industry and by many members of the Institute, in which he had always taken a very active interest.

ADMISSIONS

At a meeting of the Admissions Committee, held on the 16th October, 1957, the following were admitted to the grades shown.

Associate Fellow

C. K. Rush (on transfer from Member).

Member

P. A. Brunt, Sales & Service Rep., Aviation Electric Ltd., Montreal, P.Q.: *1692 Cardinal St., St. Laurent, P.Q.*

S/L E. G. Cameron, Development Engineer, RCAF, Ottawa, Ont.: *2009 Olympia Cres., Elmvale Acres P.O., Ottawa, Ont.*

CPO S. Cowell, Deputy/Tech. Div. Officer, RCN, Shearwater, N.S.: *Box 64, Shearwater P.O., Halifax Co., N.S.*

F. T. Dryden, Service Engineer, Rolls-Royce of Canada Ltd., Montreal, P.Q.: *Woodlawn Road, Westphal, P.O. Box 355, Shearwater, Halifax Co., N.S.*

P. O. Falconer, Test Pilot, Canadair Ltd., Montreal, P.Q.: *25 Roosevelt Ave., Apt. 14, Town of Mount Royal, P.Q.*

J. R. Gregory (on transfer from Technical Member).

J. R. Joy, Performance Engineer, Orenda Engines Ltd., Malton, Ont.: *R.R. 2, Port Credit, Ont.*

D. E. Morrison, Chief Combustion Engineer, Orenda Engines Ltd., Box 4015, Terminal A, Toronto, Ont.

H. J. W. Overal, Design Engineer, Avro Aircraft Ltd., Malton, Ont.: *Box 897, 159 Broadway, Orangeville, Ont.*

M. J. Rant, Sr. Tech. Rep., Aviation Div., S. Smith & Sons (Canada) Ltd., Toronto, Ont.: *40 Foxridge Dr., Scarborough, Ont.*

W. J. Robinson, Sales & Service Manager, The Fairey Aviation Co. of Canada, Eastern Passage, N.S.: *26 Lyngby Ave., Dartmouth, N.S.*

H. M. Stewart, Sales & Service Rep., Aviation Electric Ltd., Montreal, P.Q.: *1228 Perrot Blvd., Isle Perrot, P.Q.*

Technical Member

R. J. Beetles, Design Engineer, Canadair Ltd., Montreal, P.Q.: *2117 St. Germain, St. Laurent, Montreal, P.Q.*

D. B. Cooper, Sr. Draftsman, Trans-Canada Air Lines, Montreal, P.Q.: *768-25th Ave., Lachine, P.Q.*

F/O D. A. Fretts, Project Engineer, RCAF Stn., Cold Lake, Alta.: *c/o Officers Mess, MPO 503, Grande Centre, Alta.*

J. Harmer, Design Draftsman, Avro Aircraft Ltd., Malton, Ont.: *139 Clearbrooke Circle, Rexdale, Ont.*

CPO H. J. T. Jennings, Course Coordinator, Maint. School, RCN, Shearwater, N.S.: *64 Spikenard St., Woodlawn, N.S.*

M. Kaliczak, Design Draftsman, Avro Aircraft Ltd., Malton, Ont.: *36 Boniface Ave., East Rexdale, Ont.*

K. F. MacPherson, Design Draftsman, Avro Aircraft Ltd., Malton, Ont.: *369 East 43rd St., Hamilton, Ont.*

A. Maskell, Chief Instructor, Sales Service School, Canadair Ltd., Montreal, P.Q.: *267 Grande Cote, Rosemere, P.Q.*

W. B. McPheeters, Canadair Ltd., Montreal, P.Q.: *6100 Nelligan St., Apt. 8, Cartierville, P.Q.*

D. B. Paterson, Design Draftsman, Avro Aircraft Ltd., Malton, Ont.: *2040 Eglinton Ave. W., Apt. 210, Toronto 10, Ont.*

N. R. Roffey, Field Service Rep., Honeywell Controls Ltd., Toronto, Ont.: *Box 1070, MPO 503, Grande Centre, Alta.*

R. W. Simpson (on transfer from Student).

R. D. Thompson, Engineer–Structures, Trans-Canada Air Lines, Winnipeg, Man.: *366 Amherst, St. James, Man.*

Student

N. Abramsen, Sir George William College, Montreal, P.Q.: *4501 Decarie Blvd., No. 2, Montreal, P.Q.*

Miss R. M. Luttman, McGill University, Montreal, P.Q.: *Royal Victoria College, 555 Sherbrooke St. W., Montreal 2, P.Q.*

* * *

At a meeting of the Admissions Committee, held on the 11th November, 1957, the following were admitted to the grades of membership shown.

Member

F/L R. R. Armstrong, Staff Officer, Aero. Engr. Branch, ADC HQ, RCAF Stn. St. Hubert, P.Q.: *P.O. Box 158, RCAF Stn., St. Hubert, P.Q.*

D. R. Austin, Weight Engineer, De Havilland Aircraft of Canada Ltd., Downsview, Ont.: *327 Willow Ave., Toronto 8, Ont.*

D. Bowors, Asst. Chief Inspector, Canadian Steel Improvement Ltd., Toronto, Ont.: *R.R. No. 1, Brampton, Ont.*

W. H. Budworth, Chief Engineer, Parsons Airways Ltd., Box 120, Kenora, Ont.

P. L. Bullock, Sr. Representative, Canadair Ltd., Montreal, P.Q.: *P.O. Box 466, Agincourt, Ont.*

W. R. Burge (on transfer from Technical Member).

W/C A. Chornobrywy, Chief Tech. Services Officer, ADC HQ, RCAF Stn. St. Hubert, P.Q.: *51 Maple Drive, RCAF, St. Hubert, P.Q.*

D. R. Closson, Standards Supervisor, Avro Aircraft Ltd., Malton, Ont.: *344 Whitmore Ave., Toronto 10, Ont.*

C. A. Ford, Aerodynamicist, Computing Devices of Canada Ltd., Ottawa, Ont.: *P.O. Box 801, City View, Ont.*

J. G. Johns, Consulting Engineer, Air Div., Dept. of Lands and Forests, Provincial Govt. of B.C.: *171 The Island Highway, View Royal, Victoria, B.C.*

***Member* (Cont)**

R. N. Kelly, Stress Analyst, De Havilland Aircraft of Canada Ltd., Downsview, Ont.: *33 Erlesmere Ave., Apt. 7, Brampton, Ont.*

J. Kirby, Prelim. Design Engineer, De Havilland Aircraft of Canada Ltd., Downsview, Ont.: *3832 Bathurst St., Apt. 8, Downsview, Ont.*

CPO S. E. MacEachern, Sqdn. Chief i/c VT 40, RCN Air Stn. Shearwater, N.S.: *18 Maynard St., Dartmouth, N.S.*

C. F. Maher, Field Engineer, Westinghouse Electric Corp., A.G.T. Service Dept., P.O. Box 288, Kansas City, Missouri.

A. E. Marshall, Dept. Head, Trials Evaluation Dept., Computing Devices of Canada Ltd., Ottawa, Ont.: *Box 33, Stittsville, Ont.*

F/Sgt. D. B. McHardy, Aircraft Maint. Superintendent, RCAF Stn. Cold Lake, Alta.: *Box 1234, MPO 503, Grande Centre, Alta.*

F/L D. J. McKinnon, Aircraft Repair Officer, RCAF Stn. St. Hubert, P.Q.

J. B. Panton (on transfer from Technical Member)

F/O A. J. Robinson, Detach. Commander, TSD, Northwest Industries Ltd., Edmonton, Alta.: *11335 - 96th St., Edmonton, Alta.*

C. W. Stiles, Production Shop Foreman, Enamel & Heating Products Ltd., Amherst, N.S.: *260 Victoria St. East, Amherst, N.S.*

W. Tinning (on transfer from Technical Member)

C. Wolf, Development Project Engineer, Orenda Engines Ltd., Malton, Ont.: *212 Sandringham Dr., Downsview P.O., Ont.*

F. H. Wood, Plant Supervisor, S. Smith & Sons (Canada) Ltd. Aviation Div., 105 Scarsdale Rd., Don Mills, Ont.

Technical Member

G. B. Bedford, Group Leader–Stress Group, Canadian Car Company Ltd., Fort William, Ont.: *Oro Station P.O., Ont.*

A. Bozzer, Service Engineer, Canadian Pratt & Whitney Aircraft Co., Ltd., Montreal, P.Q.: *7549 Durocher St., Montreal 15, P.Q.*

J. H. Brown, Engine Overhaul Mechanic, Trans-Canada Air Lines, Winnipeg, Man.: *320 Moray St., St. James, Winnipeg 12, Man.*

I. Cysouw, Airframe and Engine Technician, Northwest Industries Ltd., Edmonton, Alta.: *9945 - 85th Ave., Edmonton, Alta.*

D. Dishler, Section Head–Illustrations, Canadair Ltd., Montreal, P.Q.: *553 Tait St., St. Laurent, P.Q.*

J. Kivestu, Senior Draftsman, Trans-Canada Air Lines, Dorval, P.Q.: *588 Wesluke Ave., Montreal 29, P.Q.*

E. D. Muir, Engineering Writer, Canadair Ltd., Montreal, P.Q.: *1576 Cardinal St., Ville St. Laurent, P.Q.*

E. K. Prentice, Field Service Representative, Avro Aircraft Ltd., Malton, Ont.: *c/o Officers' Mess, MPO 503, Grande Centre, Alta.*

L. V. Ursel, Technical Representative, Orenda Engines Ltd., Malton, Ont.: *1 Heatherdale Rd., Apt. 304, Toronto 14, Ont.*

Technician

J. B. Bradley (on transfer from Student)

Student

D. R. Hennig, Provincial Institute of Technology and Art, Calgary, Alta.: *729 - 15 St. N.W., Calgary, Alta.*

F. R. Ohnstad, Provincial Institute of Technology and Art, Calgary, Alta.: *1828 - 23 Ave. N.W., Calgary, Alta.*

Associate

H. D. Baker, Office Manager, Aviation Electric (Pacific) Ltd., Vancouver Airport, B.C.

SECTIONS

PROPULSION SECTION

THE development of a Propulsion Section of the Institute is making rapid progress. An Interim Committee has been set up and they have already prepared draft Section Regulations for submission to the Council. Moreover the American Rocket Society has given every encouragement to the formation of the Section and has agreed to co-operate with the Institute in such fields as the co-sponsorship of meetings and the exchange of publications.

The primary object of the Section is the provision of facilities for the exchange of information among its members particularly with regard to propulsion systems in the process of development for aircraft, missiles and the like.

The Interim Committee comprises the following:

Mr. D. H. Morrison (Orenda) Secretary
Mr. C. C. Barker (Avro)
Mr. C. D. Handley (De Havilland)
Mr. R. G. Reed (Orenda)
Mr. R. M. Sachs (Orenda)

The Committee was set up in Toronto to facilitate meeting and discussion in this formative stage but the point has no other significance; once the establishment of the Section is approved by the Council, elections will be held to set up an Executive Committee representative of all members of the Section across the country.

Tentatively, and subject to Council approval, the Identifying Qualification for membership of the Section has been expressed as follows in the draft Regulations:

"All members of the Institute who are or have been engaged in technical work on propulsion systems shall be eligible for membership of the Section."

In this definition, "propulsion systems" are taken as including engines, powerplant auxiliaries, fuels, lubricants and aircraft or missile installations having direct bearing on the means of propulsion.

Before the Council is asked to approve the formation of a Section, it is desirable that there should be some indication of the number of members of the Institute who are likely to become members of the Section. To this end, members who consider that they have the necessary qualifications are invited to apply; if admitted, they will form a "shadow" membership which will materialize when the Section is formally established. Application forms may be obtained from Headquarters or from Branch Secretaries.

It is pointed out that members of a Section must first be members of the C.A.I. but membership of a Section does not entail the payment of additional dues.

BRANCHES

NEWS

Ottawa

Reported by P. J. Pocock

September Meeting

The activity season of the CAI Ottawa Branch was launched on the 18th September by means of the now almost traditional "informal gathering" at the RCAF Gloucester Street Officers' Mess. Approximately 85 members, their ladies and guests indulged in a fine fare of food, films and refreshments. These provided a goodly stimulant to some of the more irresponsible members who were seen engaging in technical talk; not the least of these were various members of the Executive of the local Branch who held a clandestine Executive meeting off in a far corner. We owe Mr. J. E. Smith the credit for obtaining the films for the evening; they were "The History of Aviation" and "Jackpine Country".

October Meeting

From the 22nd September to the 5th October, Canada was playing host to the delegates from various Commonwealth countries who were here to attend the 5th biennial meeting of the Commonwealth Advisory Aeronautical Research Council held in Ottawa. On the 2nd October, it was the great pleasure of the Ottawa Branch to entertain the delegates to the 5th CAARC Meeting with cocktails and supper at the Gloucester Street RCAF Officers' Mess. After supper, Mr. M. B. Morgan, Deputy Director (A), Royal Aircraft Establishment, addressed the members and guests on "Some Thoughts on Aeronautical Research and Design", after which a film covering some recent activities at RAE was shown. Mr. Morgan's paper was thoughtfully philosophic and hopefully prophetic; it was received by the audience with spontaneous appreciation.

Approximately 60 people attended the evening and over half of them wrote notes on the "comments" column of their name cards to the effect that this was one of the most interesting and pleasant evenings that the local Branch has sponsored.

November Meeting

On the evening of Wednesday, 13th November, it was raining outside; inside, TV sets were tuned in to receive the Big Four play-off game. This did not augur well for another event of the evening; a double-barrel technical meeting of the Ottawa Branch to be held in the business-like quarters of Beaver Barracks. It was thought that events had stacked the cards againts the two speakers of the evening, Mr. N. L. Stoddart, Radio Navigation Engineer, Trans-Canada Air Lines, Montreal, and Mr. W. T. Curran, Head, Instrumentation Development, Computing Devices of Canada, who were to talk on "Trends in Commercial Air Navigation". It is to the credit of the speakers that there was a good meeting turn-out and a lively discussion period. Mr. Curran brought along a Mk. III Position Homing Indicator and the inveterate knob-twiddlers at the meeting were having a very enjoyable time with this device away past the bedtime of the average televiewer.

Cold Lake

Reported by F/L L. S. Lumsdaine

October Meeting

The October meeting of the Cold Lake Branch was held on the 30th October with sixteen members and guests attending. The Chairman, W/C R. D. H. Ellis, and the Secretary, F/L L. S. Lumsdaine, gave a brief resumé of the various papers presented at the IAS/CAI Meeting in Montreal, after which the November and December Branch programmes were discussed. A mixed meeting to see the films "The Back of Beyond" and "The Birth of an Oil Field" was arranged for the 26th November and plans finalized for a Branch visit to Edmonton in December. Two Shell films, "Prospecting for Petroleum" and "The Rival World", were then shown to the gathering.

Unfortunately, the Aeromedical symposium which was scheduled for this meeting was cancelled due to a change in the itinerary of the I.A.M. team, brought about by aircraft delays.

Edmonton

Reported by C. W. Arnold

October Meeting

The October meeting of the Edmonton Branch was held at 700 Wing, RCAF Association Mess on Tuesday, 15th October, at 8.00 pm.

After a short business meeting, Mr. H. Stapleton, Branch Vice-Chairman, introduced the guest speaker, Mr. P. Strong, who gave a most interesting and amusing commentary on his film "Wings over Africa". This film featured magnificent panoramic shots of the Cape of Good Hope, the mountains of Basutoland, wild game in Zululand and the Zambezi River, Victoria Falls, also orange plantations and aerial spraying in Golden Valley, Natal.

Mr. Strong pioneered one of the first air routes across the mountain territory of Basutoland in 1948, providing passenger, airmail and freight services under contract to the British Government. The development of these services was illustrated by the following figures:

1948-49	400 passengers and 50 tons freight
1952-53	5,000 passengers and 2,000 tons freight

Another film, entitled "Flight Log", was then shown. Both films were much appreciated by the forty-five members and guests present at the meeting.

Mr. Strong was thanked by Mr. C. C. Young and the meeting was then adjourned.

Toronto

Reported by I. A. Rankin

October Meeting

The October meeting of the Toronto Branch took the form of a visit to the production facilities of Orenda Engines Ltd. Those attending, 112 in all, toured the plant in several small groups under the expert guidance of a number of Orenda employees.

Prior to the tour, Mr. F. H. Keast, newly appointed Chief Engineer at Orenda, gave a short talk in which he covered some of the basic considerations behind the design of Orenda's latest product, the Iroquois. The considerations of security prevented discussion of important details, but some idea of the problems which were and are being solved in the development of this engine was gained.

Light refreshments were served by the hosts of the evening at which time Mr. J. W. Ames, Chairman, said a few words appropriate to the occasion.

SUSTAINING MEMBERS

NEWS

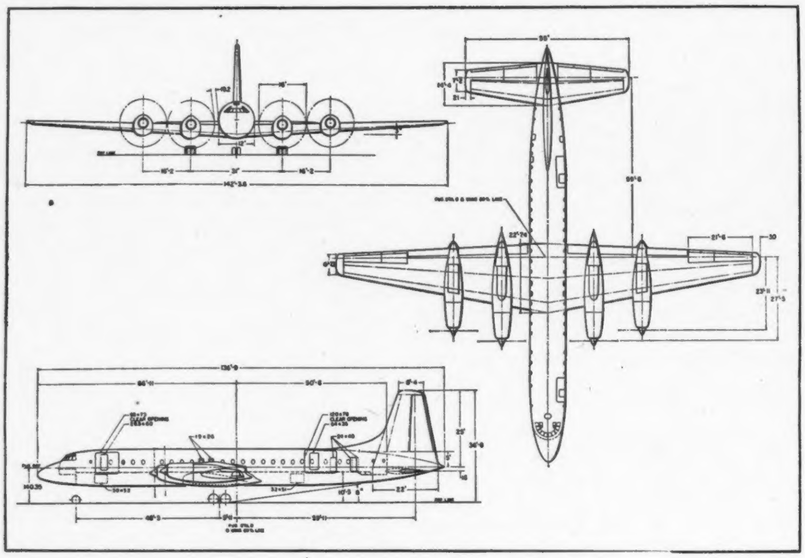
The De Havilland Aircraft of Canada Ltd. held a brief ceremony on the 31st October to hand over the first of six Otter aircraft ordered by the Indian Air Force. The aircraft was accepted by S/L P. N. Khanna, Assistant to the Indian Air Attaché. The delivery schedule runs through to July, 1958.

The Otters were selected by the Indian Air Force after competitive evaluation based on rigorous tests which included mountain flying trials, high altitude and short landing checks and supply dropping demonstrations in mountainous frontier areas. During the evaluation, the Otter demonstrated that, in high temperatures, it approaches helicopter performance but has greater payload and necessitates fewer manhours for maintenance.

The tasks of the Indian Air Force Otters will be similar in scope to those of the Otters with the United States Army and Navy, the RCAF, the Norwegian Air Force and the Chilean Air Force – the rapid movement of organic equipment, supplies and personnel, search and rescue missions, as aerial ambulances and for air-drop resupply. Over two hundred Otters are presently being used for military and civil purposes throughout the world. The bulk of these, in service with the United States Army, in addition to the utility transport application, are used for topographical survey and photographic missions in the Arctic and in the tropics.

In addition to their military role, the Indian Air Force Otters will be available to provide casualty evacuation, flood relief and other services to remote areas.

The TECO Model TE-569 seat



General arrangement of the CL-44

Railway & Power Engineering Corporation Ltd., as Canadian representatives of Teco Inc. of Burbank, California, are supplying the TECO Model TE-569 seat to Canadian Pacific Air Lines for installation in their Britannia fleet. One of these seats, with Mr. R. J. Conrath, Railway & Power Engineering, Mr. J. A. Gillies, C.P.A.L., and Mr. G. K. Jones, President of Teco Inc., is shown in the picture below. The seat, which is available in double and triple units, has adjustable head rests and recline adjustments, individual ash-trays, life rafts and floatation-type cushions and, at the back, fold-away food tables and extra high shin clearance. They are basically of welded chrome-moly tubular construction.

Canadair Ltd. has announced the development of a jet trainer known as the CL-41. Two prototypes are being built; they are expected to be completed in the fall of 1958. The aircraft is intended for ab initio and basic training. It includes side-by-side seating, cabin pressurization and ejection seats.

The general lines of the aircraft can be seen from the picture of the mock-up shown herewith. General dimensions are: span 36'4", length 31'11", height 9'½", wing area 220 sq ft. Gross weight is 6,250 lb. The type of engine to be installed has not yet been announced but it will have a static thrust of the order of 2,000 lb. A speed range from 62 kts, stalling, to 400 kts, maximum, military power, is expected. Sufficient fuel capacity is provided for two hours of circuits and landings at sea level without refuelling.

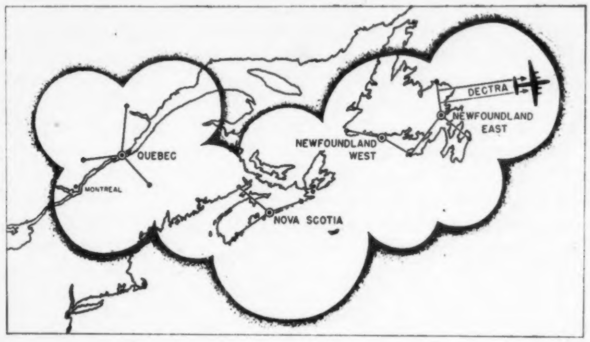
The announcement of the CL-41 followed by a few weeks the announcement of the CL-44, at the other end of the Canadair scale. The CL-44 is a transport aircraft developed from the CL-28 Argus, but it is very much larger, with a 25% increase in range and a 100% increase in cruising speed. Gross weight of the CL-44 will be 205,000 lb. It will be powered by four Bristol Orion turboprop engines.

There will be three versions of the CL-44, military (now on order for the RCAF), airliner and freighter. The airliner can be used in a variety of seating arrangements, carrying 154 passengers in the "thrift" class configuration. As a freighter, a payload of 35 tons can be carried.

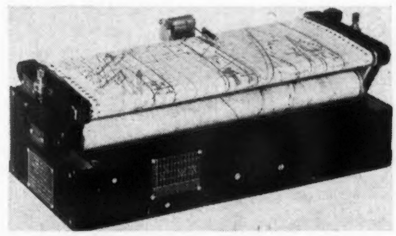
The general layout and dimensions can be seen in the drawing above.

Mock-up of the CL-41

Specially prepared charts on which a moving pen records an exact position and track make navigation in Bendix-Decca equipped aircraft simple and accurate. The "flight log" which interprets continuous signals from the ground stations to give immediate course and position information is seen in the centre of this photograph



The one-million-square-mile area outlined on this map is covered by the Bendix-Decca navigation system. The system is tied in with its long-range companion, Dectra, which is in operation for the North Atlantic air route



This "highway map" plots the exact position of the aircraft at all times as a black line traced on the chart by the pen.

Spartan Air Services Ltd. have started operations with Vertol 42-A helicopters along the Mid-Canada Line, airlifting personnel and supplies from Hudson Bay to Labrador. The machines, the first 42-A's to be civilly licensed in North America, are a commercial model of the military H-21.

THE BENDIX-DECCA SYSTEM

A Bendix-Decca Navigation Chain was inaugurated in Quebec on the 5th November by Mr. J. R. Baldwin, Deputy Minister of Transport. The installation is at present for evaluation purposes only, to determine its usefulness to aviation and shipping, and has been carried out as a private venture, with Department of Transport authority. In connection with this development, Computing Devices of Canada Limited, which holds the Canadian rights to both the Decca and Dectra systems, has issued the following information.

What it is

The Bendix-Decca system is a low-frequency radio navigation aid designed to provide precise "maps in the sky" for economical and practical air traffic control – from departure and climb to in-flight checks and arrival at the terminal area. It will show at any moment where an aircraft is, where it has been, its heading, distance covered, distance to go and ground speed.

A "road map" or flight log mounted in the cockpit automatically provides a continuous pictorial display to the pilot of his track in relationship to his take-off point and destination. It permits maximum utilization of air space at all flight altitudes. With it, a pilot can maintain minimum track separation.

The long-range companion of Decca is called Dectra.

The area-coverage system, based on the phase comparison of continuous wave transmission, operates in the 100 kilocycle band. Transmissions from the sending stations are phase-locked. This technique permits overlapping of the phase patterns that are produced between stations to form a 360° navigational grid. The grid is made by the lines of phase difference transmitted by the stations.

The system requires the use of groups of "chains" of ground transmitting stations, consisting of "master" and "slave" stations that transmit wave patterns occupying precisely known and stable geographical positions. Each Decca chain consists of the master, identified as "black", and three slave stations, "green", "red" and "purple". A continuous "fix" or location is provided by the intersection of position lines supplied by radio signals from two stations. These position lines are detected by a receiver and the information is recorded on dial indicators, called decometers, and also displayed instantly and automatically on the flight plotter.

This "highway map" consists of a specially prepared navigation chart of the area being covered with the electronic position lines printed over it. A pen tracks the position of the aircraft on the map and provides the precise navigational information to the pilot.

The new chain established in Quebec is the first of its type to be constructed in North America. Called a Mark 10 chain, it will improve night-time coverage and transmit a signal to provide automatic lane identification with high accuracy, as well as identify the zone in which a plane is travelling.

Who is using it

Both Bendix-Decca and Bendix Dectra can be used for aviation and marine navigation. For example, it is being evaluated in Europe to modernize air traffic control; and an aerial "traffic cop" system, based on Decca, was instituted for evaluation last year for the London flight information region.

The techniques in this area for aircraft equipped with the Decca equipment permitted the setting up of "double-barrelled" air lanes, which permit air traffic to climb and descend through all altitudes with precisely known lateral separation. This lateral separation is provided by the use of parallel Decca tracks on opposite sides of an 11½ mi wide (10 nautical miles) airway. Each Decca track is located about 1.2 mi from the edge of the airway.

With aircraft flying in the same direction at the same altitude, both lateral and longitudinal separations are used. This has enabled Decca-equipped traffic to be spaced 5 min apart, instead of the usual 10 min. Decca-equipped aircraft are separated immediately, which has reduced the takeoff separation time from 5 to 2 min.

In connection with the introduction of this Decca flight procedure, the British Ministry of Transport noted that it was done to take advantage of the "high accuracy" of the system, "which will expedite traffic by employing reduced separation standards".

In economic terms, Bendix-Decca is of impotance to the aviation industry, particularly with the use of jet airliners on commercial routes. For example, a Viscount uses an extra gallon (US) of fuel for each 2.32 mi flown when operated in a holding pattern at altitudes between 2,000 and 5,000 ft. If held at the low altitude, by jet standards, for 34.6 mi an extra 15 gals of fuel are used, amounting to 119 lb.

The need for more precise scheduling, particularly in the jet age, is also apparent from the following figures: in England present longitudinal separations of aircraft not equipped with Decca require that aircraft be spaced at a minimum of 10 min apart when they are on the same airway and at the same altitudes. This means a separation of 35 mi between DC-3's, 46 mi for Convairs and 58 mi for DC-7's. The spacing will require above 81 mi for future jet airliners.

Some estimates have placed the savings in flight time on some routes as high as 11% for Bendix-Decca-equipped aircraft. The flight time can be saved because of the accurate navigation information supplied to the pilot as he leaves a holding pattern and lines up his aircraft for the ground approach.

In connection with the opening of the Quebec Bendix-Decca chain on Nov. 5, the first trans-ocean flight of an aircraft using the navigation aid on the North Atlantic route between England and the Canadian mainland was made by a Valiant bomber operated by an RAF crew for the British Ministry of Supply. Takeoff point was Boscome Down in the south of England. Its route was from Boscombe via Ireland on short-range Decca chains, switching to long-range Dectra for the trans-Atlantic crossing from Ireland to Gander. From Gander to Quebec, it flew on Decca coverage provided by chains opened during the summer in Newfoundland and Nova Scotia.

These chains, along with the Quebec chain, cover an area of one million square miles. In addition to providing a precise navigation aid for aircraft, they also will enable trans-Atlantic ships to make Cape Race and also provide coastal navigation for all types of ships, including fishing vessels and shippers on the St. Lawrence route.

Decca has been used for years in European waters, giving continuous track and position data to ships without the necessity for taking conventional fixes. The system was first used because of its accuracy and reliability to guide the allied invasion forces in the Normandy landings of World War II. After the war, it was used by commercial interests on the British coast and now covers most of Europe. More than 4,000 ships are now fitted with Decca receivers, including the Queen Elizabeth, Queen Mary, United States and the America.

Its future application

The flexibility of Bendix-Decca in its application to the air traffic control problem is based on its ability to meet local conditions at the terminal area. These conditions may be due to the weather or to local traffic control operations and requirements.

For example, holding areas in a terminal area can be set up and changed as often as needed without moving ground equipment; the size of the air space for each holding pattern can be held to a precise minimum dependent upon local conditions; and since a pilot knows his precise position at all times with the pictorial display of his "track" before him, he is able to leave the area at an exact time designated by the control tower, thus helping to facilitate the flow of traffic in landing. It also enables the pilot to report his precise position to the tower controller who, in turn, can quickly identify a reporting aircraft on a radarscope without complex air-ground communications.

In addition, any desired number of approach and departure "tracks" can be set up and displayed on the flight chart – a pilot being told to follow a specific line or track – with radar being used in the role of a monitor by air traffic control.

APPOINTMENT NOTICES

The facilities of the Journal are offered free of charge to individual members of the Institute seeking new positions and to Sustaining Member companies wishing to give notice of positions vacant. Notices will be published for two consecutive months and will thereafter be discontinued, unless their reinstatement is specifically requested. A Box No., to which enquiries may be addressed (c/o The Secretary), will be assigned to each notice submitted by an individual.

The Institute reserves the right to decline any notice considered unsuitable for this service or temporarily to withhold publication if circumstances so demand.

Positions Required

Box 102 **Publications Engineer:** Aero engineering graduate, eight years experience in aircraft industry, requires position of responsibility and chance to widen his experience.

Box 103 **Sales or Administration:** Canadian with 22 years aviation experience in purchasing, sales, administration, seeks challenging position in Sales or Administration.

Positions Vacant

Electronic Engineer: For design on varied projects in airborne and industrial electronics. Work includes analog and digital measuring and control systems, servos and automatic information handling. Applicant should have degree in electrical engineering, engineering physics or radio physics and have at least five years relevant experience. George Kelk Limited, 130 Willowdale Ave., Willowdale, Ont.

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of the

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The following examples illustrate the form in which the Notices will be presented and they should be drafted accordingly:

Positions Vacant

Electronic Engineer — To work with Flight Test Group in automatic data handling and telemetery. Candidates should have a good engineering degree and at least five years experience in similar or related work. Applications should be submitted in the first place by letter to the Chief Engineer, Phantom Aviation Company Limited, Mapleleaf, N.W.T.

Positions Required

Box ABC. **Aeronautical Engineer** B.Sc. Ten years airline and maintenance experience. Broad administrative background including sales and contracts. Desires position with airframe manufacturer in liaison engineering or customer service capacity.

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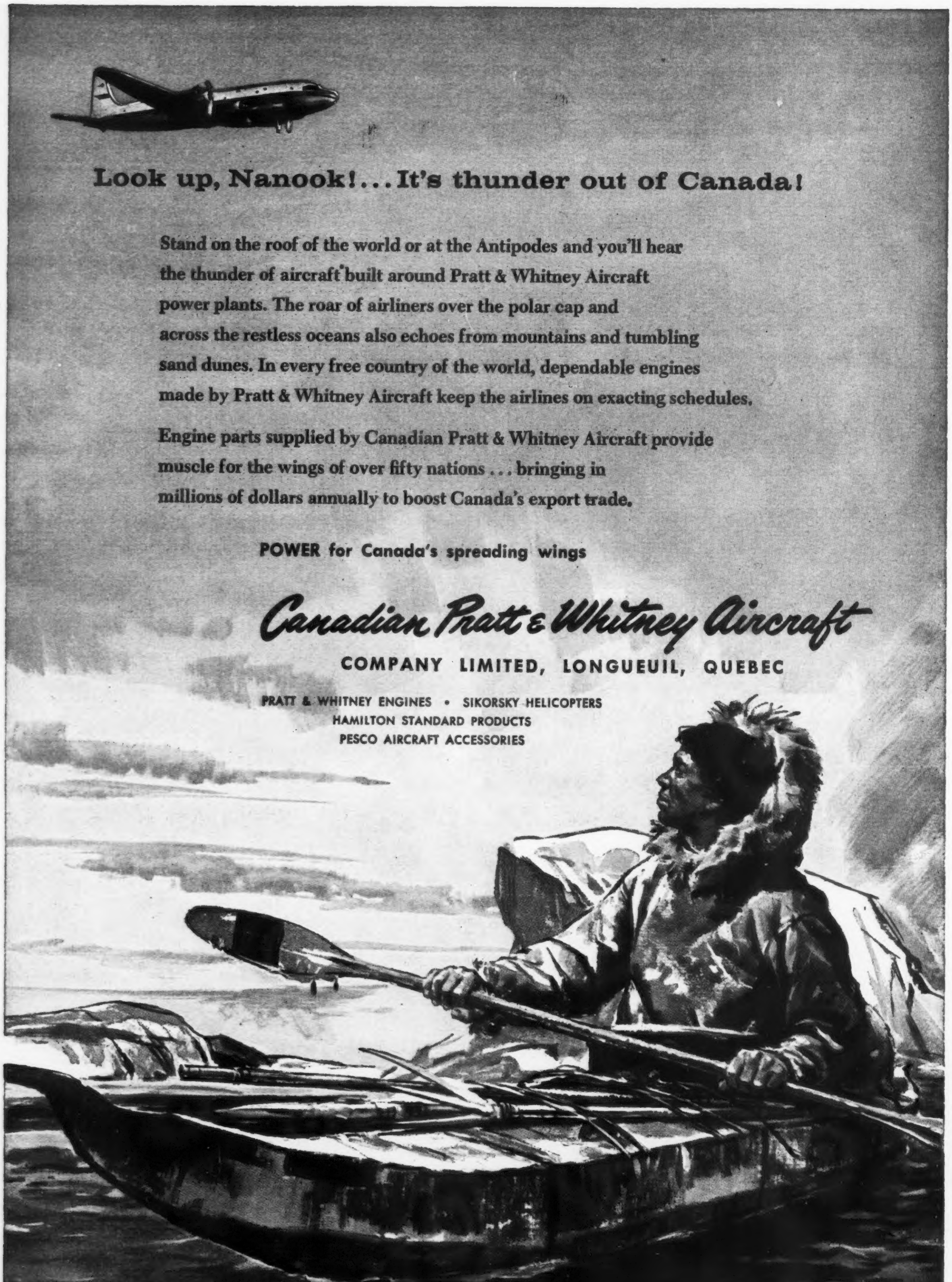
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BRITANNIAS WILL BRING NEW LOOK TO CANADIAN PACIFIC AIR ROUTES

Canadian Pacific Airlines to introduce world's biggest, fastest, quietest airliner to transpolar and intercontinental air routes early next year

The Bristol Britannia, the world's biggest, fastest and quietest airliner is coming into service on all major Canadian Pacific air routes early next year. These magnificent new aircraft will bring new standards of speed and luxury to Canadian Pacific passengers, flying over the North Pole on European routes, to and from South America and across the Pacific to Tokyo and Sydney.

Britannias are in commercial service with British Overseas Airways Corporation. They have also been ordered by Aeronaves de Mexico, Cubana de Aviacion, El Al Israel Airlines, Hunting-Clan Air Transport, Northeast Airlines, Royal Air Force Transport Command, and the British Ministry of Supply.

Two Britannia derivatives now building in Canada will also give a new look to the Royal Canadian Air Force. These are the long range maritime reconnaissance CL28 Argus and the military transport CL44, both being built by Canadair Ltd.

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